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SURGICAL DIAGNOSIS

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SURGICAL DIAGNOSIS

BY

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VOLUME III

THE SPINE · THE NERVES · THE PELVIS · THE EXTREMITIES

APPENDIX

WITH ONE COLORED PLATE AND TWO HUNDRED AND SEVENTY-FOUR ILLUSTRATIONS IN TEXT

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SURGICAL DIAGNOSIS

VOLUME III

CHAPTER I

INJURIES OF THE SPINE AND SPINAL CORD

ANATOMICAL AND PHYSIOLOGICAL NOTES

(Partly adapted from Woolsey, "Applied Surgical Anatomy," from Merkel, and from Joessel.)

In examining the spine it is to be observed that the spine of the seventh, sometimes of the sixth, cervical vertebra is notably prominent at the back of the neck (vertebra prominens) and forms a convenient landmark from which to count the lower vertebræ. The first dorsal vertebra is still more prominent. The third dorsal spine is at the level of the inner end of the spine of the scapula; the seventh is opposite the lower angle of the scapula; the fourth lumbar spine is at the level of the highest point of the iliac crest (this last forms the landmark for the operation of lumbar puncture); the second sacral spine is opposite the center of the sacro-iliac joint. The dorsal spines pass obliquely downward, while the lumbar spines project horizontally and correspond with the bodies of their vertebræ. Viewed laterally, the spinal column presents at birth a thoracic and a sacral curve, convex backward. After the erect posture is assumed, two other compensatory curves are developed—a cervical and a lumbar curve, convex forward. These latter curves are necessary for the assumption of the erect posture, and depend largely upon the thickness of the intervertebral disks. In old people they may be lost from absorption of these disks. The head then projects forward and the convexity of the dorsal region becomes exaggerated. The gait and the posture in walking thus produced in aged people are quite characteristic. The antero-posterior curve of the spine may be exaggerated in disease of the spinal vertebræ and in disease of the hip-joints. By disease of the bodies of the dorsal vertebræ, usually of a tuberculous character, the bodies of the vertebræ become softened or destroyed, and a marked angular projection of the dorsal spine results—kyphosis, or humped-back. In disease of the hip-joint, the lumbar curve, convex forward, may be exaggerated, in order to compensate for the flexed position of the hip-joint. The entire pelvis tilts forward and the lumbar curve is greatly increased, thus enabling the patient to walk in the erect posture. (See Coxitis.) This exaggerated lumbar curvature is known as *lordosis*. Lordosis is often marked in pregnancy, obesity,

and in the presence of large tumors and extensive exudates in the abdomen; also in congenital dislocation of the hip. Lateral curvature of the spine is known as *scoliosis.* (See Scoliosis.)

The movements between the individual vertebræ are for the most part slight, but in the aggregate considerable. Motion is most free in the cervical region, where the surfaces of the articular processes are more nearly horizontal, the bodies of the vertebræ smaller and of relatively considerable height. Rotation is most free in the atlo-axoid joint, and flexion and extension in the occipito-atloid joint. In the lumbar region flexion and extension are quite free, but lateral motion is limited by the large surfaces of the bodies of the vertebræ, and rotation, by the articular processes. Lateral mobility is limited in the dorsal region by the presence of the ribs. In the dorsal region the laminæ afford a very perfect protection for the spinal cord behind. In the cervical and lumbar regions this protection is less complete, and in the upper cervical region a narrow, sharp instrument—a needle or a dagger, for example—may be introduced between the vertebræ and injure the cord. Homicidal wounds are occasionally made in this way.

Lumbar Puncture.—In the lumbar region it is also possible to enter the spinalcanal with a narrow instrument introduced to one side of a lumbar spine and thrust forward and a little upward. This mode of entering the spinal canal is utilized for diagnostic and therapeutic purposes and for cocainization of the spinal cord. Since the spinal cord extends to the lower border of the first lumbar vertebra, the puncture is usually made between the second and third or between the third and fourth lumbar vertebræ.

The operation is of great diagnostic value, both in injuries and diseases of the brain and its membranes, to detect the presence of intermeningeal hemorrhage or of pathological characters of the cerebro-spinal fluid of other sorts, and also in injuries and some diseases of the spinal cord. If performed with due aseptic precautions, the operation is devoid of danger. Before introducing the needle the skin at the proposed site of puncture may be rendered insensitive by freezing with ethyl chlorid. The needle used should be about three inches in length and one sixteenth of an inch in diameter. The operation may be performed while the patient is sitting up; or perhaps with greater safety while lying down. In the former case the patient sits with the body bent forward to increase the space between the laminæ. In the latter the patient lies upon the left side, near the edge of the bed or table, the head bent forward and the thighs flexed as far as possible.

In adults the puncture is best made between the third and fourth arches; in children, one or two spaces lower. The fourth lumbar spine is readily identified, at the level of the crest of the ilium. The needle is introduced about three quarters of an inch from the median line, to avoid the spines, and at the level of the middle of the spine below the interval it is desired to enter. The needle is thrust gently forward and, in adults, a little upward, a distance which varies from 2 cm. in infants to 8 cm. in large adults. The stylet is then withdrawn,

and the escape of cerebro-spinal fluid from the needle indicates that the subarachnoid space has been entered. From 5 c.c. to 10 c.c. may be withdrawn. The fluid may then be preserved for microscopical examination for blood, cellular elements, bacteria, etc. It is customary in *spinal cocainization* to withdraw only so much fluid as is to be replaced by cocain solution; so that the

FIG. 1.—THE SPINAL COLUMN FROM BEHIND. (After Merkel.)

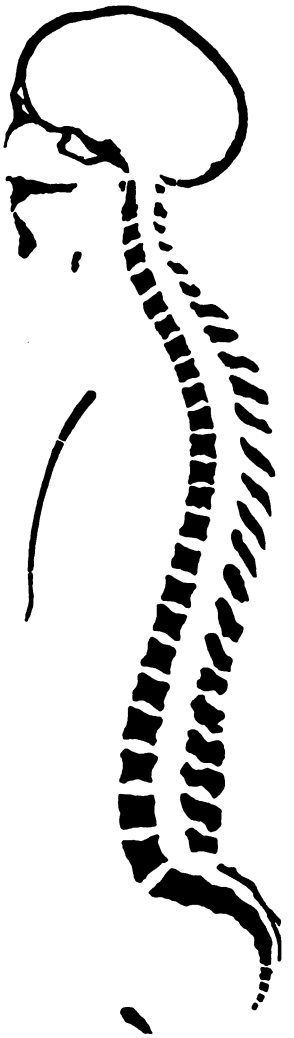

FIG. 2.—THE CURVES OF THE SPINAL COLUMN. (From Merkel, after Henle.)

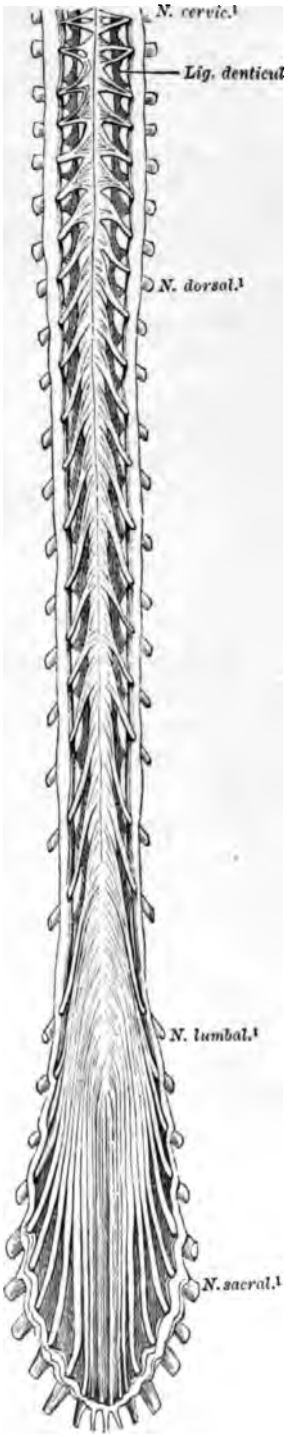

FIG. 3.—THE SPINAL CORD FROM IN FRONT. (After Merkel.)

intraspinal pressure may remain unchanged. The normal pressure is equivalent to about 2 inches of water.

In inflammations of the spinal membranes, or in greatly increased intraspinal pressure from hemorrhage within the skull or the spinal canal, an increase of pressure is observed in the cerebro-spinal fluid. The character of the fluid is of diagnostic importance. Normally the cerebro-spinal fluid contains only a trace of albumin—0.05 per cent. In inflammation it may be rich in albumin. Cultures may be made from the fluid withdrawn in cases of suspected tubercular meningitis, cerebro-spinal meningitis, or in septic conditions involving the cerebro-spinal canal. Microscopically, blood may be found in cases of injuries of the brain, in cases of spinal injury with hemorrhage, and in cases of pachymeningitis. Pus cells may be found, as well as blood, in inflammatory conditions.

The Spinal Cord.—At birth the spinal cord extends downward as far as the third lumbar vertebra. In the adult it extends as far as the lower border of the first lumbar vertebra. When the body is bent forward and the arms elevated the lower end of the cord rises about half an inch. The spinal membranes extend as low as the level of the third sacral spine, and the cavity of the membranes may thus be wounded at a level considerably below that of the cord. The cervical enlargement of the cord lies opposite the fifth and sixth cervical vertebræ, the lumbar enlargement opposite the twelfth dorsal vertebra. The spinal cord does not fill the spinal canal. The cord is surrounded by the dense, firm membrane, the dura, which sends off processes surrounding the roots of the spinal nerves. The dura is continuous with the dura of the cranium, but, unlike it, does not form the periosteum of the vertebræ. A considerable space exists outside the dura, filled with fat and loose connective tissue containing many thin-walled veins. The protection of the cord is thus very perfect against external violence. It hangs suspended within its canal, and often escapes injury after even severe mechanical shocks to the vertebræ. The dura is exceedingly tough, and even when the cord itself is completely crushed and destroyed the dura usually remains untorn.

The veins overlying the dorsal surface of the arches of the vertebræ communicate freely with the venous plexuses of the spinal canal, and thus septic infection may travel from without and cause meningitis. Such infection may follow infected wounds, carbuncle of the back, or deep bed-sores. The dura and the arachnoid membrane of the cord are in contact, but beneath the arachnoid there is a considerable space filled with cerebro-spinal fluid surrounding the cord. This fluid communicates both with the fluid surrounding the cerebrum and with that contained in the lateral ventricles. The cord hangs in this fluid, supported on either side by the nerve roots and by the ligamenta denticulata; posteriorly by the septum posticum.

Relations between the Spines of the Vertebræ and Segments of the Cord.—The relations between the different segments of the spinal cord and their nerve roots to the spines and bodies of the spinal vertebræ is shown in

Fig. 7. These relations are not absolutely constant. Chipault formulated the following rules for determining the relation of the segments of the cord to the spines of the vertebræ. It is thus quoted by Starr:[1]

In the cervical region add one to the number of the vertebra and this will give the segment opposite to it. In the upper dorsal region add two; from the sixth

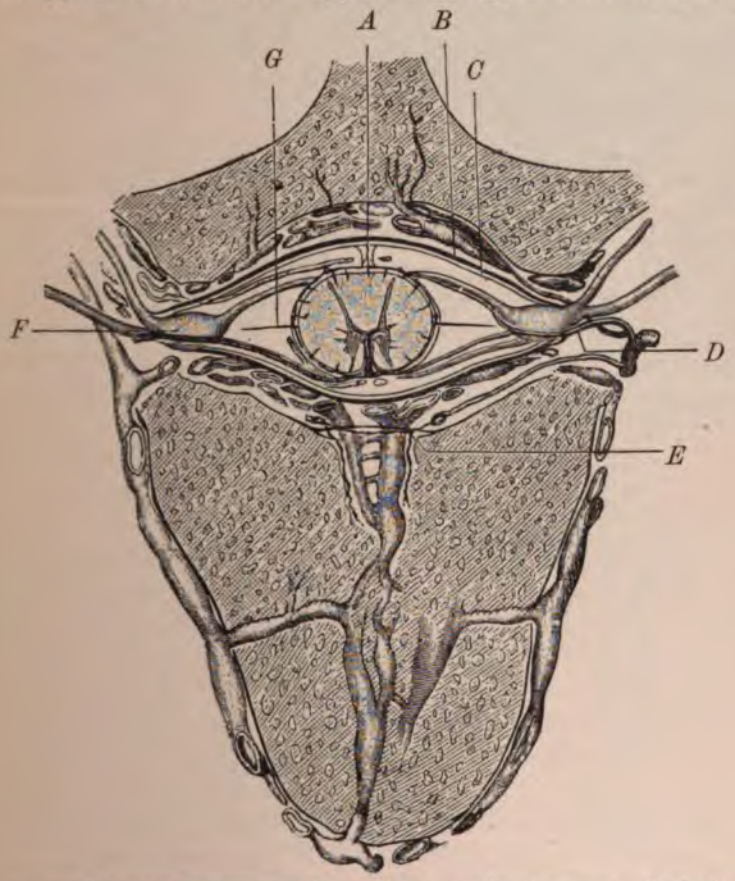

Fig. 4.—Transverse Section through the Spinal Canal and Its Contents. Partly diagrammatic. *A*. Septum posticum. *B*. Dura. *C*. Arachnoid. *D*. Arterial branch to cord. *E*. Posterior longitudinal ligament. *F*. Ganglion. *G*. Ligamentum denticulatum. (After Merkel.)

to the eleventh dorsal vertebra add three. The lower part of the eleventh dorsal spinous process and the space below it are opposite the lower three lumbar segments. The twelfth dorsal spinous process and the space below it are opposite the sacral segments.

Functions of the Spinal Cord.—In order to properly diagnosticate the surgical injuries and diseases of the spinal cord it is necessary to know something of the functions of the cord as a whole and of the different portions of the cord in detail, in so far as disturbances of these functions are important in the

[1] M. A. Starr, "Organic Nervous Diseases," first edition, p. 369, 1903 (Lea Brothers).

diagnosis of surgical conditions. The following data are partly adapted by permission from Starr: [1] The cord is made up of thirty-one segments of gray matter, each of which is connected with a pair of spinal nerves passing to some region of the body, and connected with the brain and with the other segments by nervous tracts which run into the columns of white matter surrounding the central gray substance of the cord. The functions of the cord are of two kinds: (1) the direct control of the parts of the body with which it is connected by its spinal nerves; (2) the transmission of motor and sensory impulses to and from the brain.

SYMPTOMS OF INJURY AND DISEASE OF THE SPINAL CORD

The symptoms of injury and disease of the spinal cord are paralysis, disturbances of the motor and sensory reflexes, disturbances in the anal and vesical sphincters, changes of gait and posture, ataxia, disturbances of sensation, pain, vasomotor, and trophic disturbances. It will be necessary to consider these various symptoms in detail in so far as they are connected with injuries and such spinal diseases as may be treated by surgical means.

Paralysis

Weakness or total loss of power may affect one muscle, or a group of muscles, or an entire limb. Such paralysis may be due to a lesion of the cerebral cortex, or to a lesion in the motor paths anywhere between the cortical motor center and the motor cells in the anterior horns of gray matter in the cord. The motor paths of the cord lie in the lateral pyramidal and anterior median columns. Paralysis due to this cause is known as cortico-spinal paralysis (central neuron), and is quite different, as will be noted, from paralysis due to lesions in the motor cells of the cord itself—spino-muscular paralysis (peripheral neuron).

For a proper understanding of the several forms of paralysis which may affect the muscles it is necessary to note the mechanism whereby voluntary movements are produced and controlled. The following description is partly adapted from Bailey's "Diseases of the Nervous System Resulting from Accident and Injury," second edition, page 68 *et seq:*

Voluntary movements are presided over by the motor cells which are situated in the gray matter around the fissure of Rolando. It is in the cells of this region that the motor pathway has its beginning, and the motor pathway (see Fig. 5) is the cerebro-spinal tract of which our knowledge is most complete.

It descends through the brain as a well-defined bundle of nerve fibers which terminate in the basal ganglia, the pons, the medulla, and the anterior horns of the spinal cord. Before reaching the spinal cord the larger number of these fibers decussate, those for the cranial nerves in the pons and in the upper part of the

[1] Starr, *loc. cit.*, p. 165 *et seq.*

medulla, and those for the spinal cord in the lower part of the medulla. By this crossing, the cerebral fibers for motion have their termination in the opposite side of the cerebro-spinal axis to that from which they came. The continuation of the motor tract from the gray matter of the brain axis and spinal cord is in the peripheral nerves, which are distributed to the muscles.

The entire tract for voluntary motion, from cortex to periphery, is composed of aggregations of nervous units which are called motor neurons. A neuron, a term proposed by Waldeyer to include the nerve cell in its entirety, consists of (*a*) the cell body, (*b*) the protoplasmic processes or dendrites which are generally supposed to convey impulses to the cell and are consequently afferent, and (*c*) the axis cylinder of the cell, or the

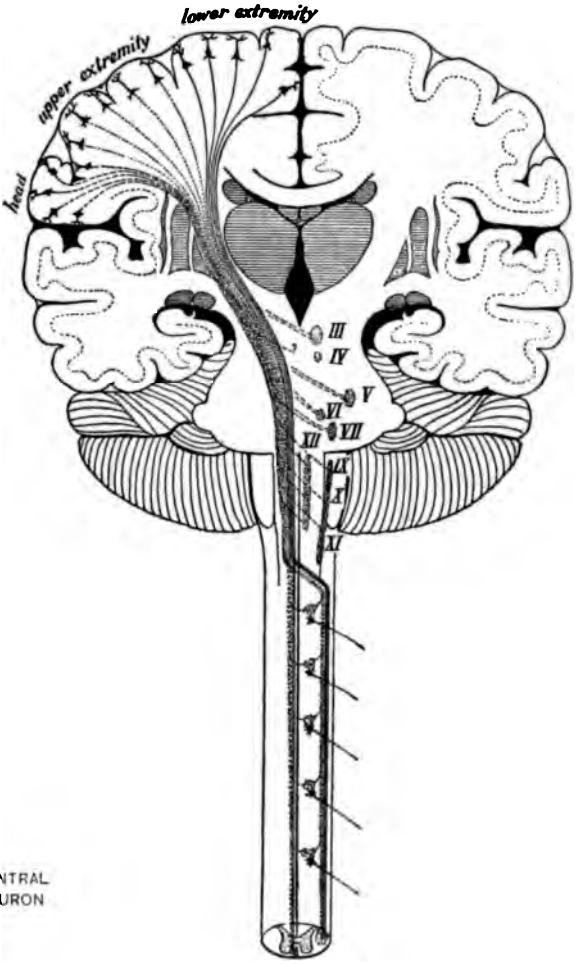

FIG. 5.—SCHEMA ILLUSTRATING THE COURSE OF THE CEREBRO-SPINAL MOTOR PATH. (Bailey, after Van Gehucten.)

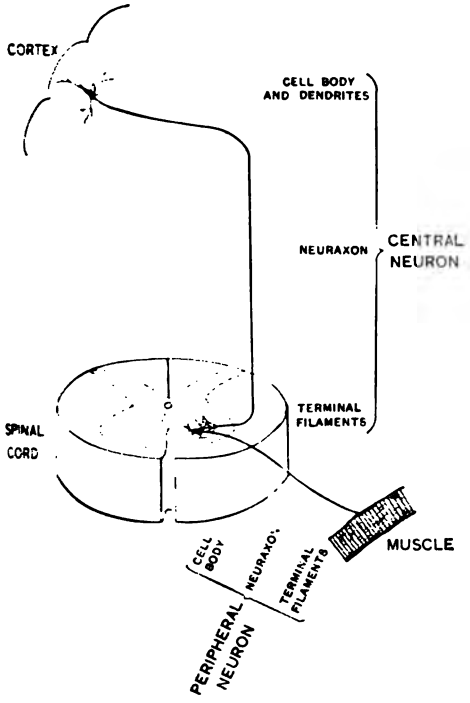

FIG. 6.—SCHEMA TO ILLUSTRATE THE ARRANGEMENT OF THE MOTOR NEURONS. (Bailey.)

neuraxon, which is known to convey impulses from the cell and is consequently efferent. The cerebro-spinal motor pathway is principally made up of two sets of these neural elements, which are called respectively *central, upper,* or *secondary neurons,* and *peripheral, lower,* or *primary neurons.* The cell body of the central neuron is situated in the motor cortex of the brain, and its neuraxon descends through the motor pathway, to

be connected by fine terminal filaments with the peripheral neuron. The peripheral neuron connects the gray matter of the brain axis or of the spinal cord, as the case may be, and the periphery. Its body is in the gray matter, where it is closely associated with the terminations of the central neuron; its neuraxons form the motor fibers of the peripheral nerves. A voluntary movement is the result of some change, the nature of which is unknown, in the cortical part of the central neuron, by which an impulse is liberated and caused to descend the neuraxon. Its energy is then transferred by means of the terminal filaments to the peripheral neuron, along which it passes to the muscle fiber, which it stimulates and causes to contract. When for any reason the creative power of the cell body of the central neuron is abolished, or the conductivity of its lower part or of the peripheral neuron is lost, the muscles which are controlled by these elements cannot receive the stimulus necessary for their contractions and are consequently paralyzed.

The clinical manifestations of paralysis vary according as the lesion exercises its inhibitory or destructive action upon the central or the peripheral neuron.

Symptoms of Central Neuron Injury:	Symptoms of Peripheral Neuron Injury:
Paralysis.	Paralysis.
Rigidity.	Flaccidity.
Increase of tendon reflexes.	Loss of all reflexes.
Babinski phenomenon.	Degenerative electrical reactions.
Loss of peripheral reflexes.	Atrophy early and decided.
Preservation of normal electrical reactions.	Trophic disturbances prominent.
Atrophy slight or absent.	
Trophic disturbances not prominent.	

Bailey further states that:

Exception must be made for the distinctive character of these symptoms in so far that after acute injuries all reflexes may be absent for a time, paralysis may remain flaccid for hours or days, and that at least five days are necessary for the development of degenerative electrical reactions. The pure type of central neuron paralysis is rarely seen except in injuries occurring in or above the basal ganglia of the brain. In these situations none of the neuraxons have reached their lowest destination, and since a peripheral neuron does not begin until its central neuron ends, there are no peripheral neurons in the vicinity of the lesion and the paralysis accordingly corresponds to the central neuron type. The pons, medulla, and spinal cord, on the other hand, contain such peripheral neurons as are making their exit from the cerebro-spinal axis (cranial and peripheral nerves), and also those central neurons which are still descending to be connected with the peripheral neurons which were situated at lower levels. Consequently, while injuries of the cerebrum present symptoms referable to lesions of the central neurons only, those at the base of the brain or in the spinal cord usually give evidence of interference with both neurons. Thus an injury to one side of the pons in a situation below the crossing of the facial nerve causes a facial palsy on the same side as the lesion (peripheral neuron), while the paralysis of the arm and leg is on the other side of the body and of central neuron type.

Cortico-spinal Paralysis.—To review the characteristics of cortico-spinal paralysis (central neuron type) a little more in detail the following may be observed: The muscles are partly, not absolutely, paralyzed. All the muscles of the affected limb are about equally involved. The muscles are rather rigid, and the joints can, therefore, be moved only with difficulty. The muscles contract promptly when the muscle itself or its tendon is tapped. The muscles do not atrophy, but may diminish in size from disuse. Their electrical reactions remain normal. The circulation of the limb is somewhat impaired; the skin is a little blue and cool; there is often edema of the extremity. Sensation remains normal, or if disturbances of sensation exist, they indicate the presence of disease outside of the motor tract. Such paralysis is common as the result of many forms of cerebral disease, and then usually affects one half the body (hemiplegia). If it originates in the cord and is due to a transverse lesion, the paralysis will affect both lower extremities; or if the lesion is in the cervical portion of the cord the arms will also be involved. Such lesions are sometimes caused by pressure; in Pott's disease (tuberculosis of the bodies of the vertebræ), by the pressure of the tumor of a

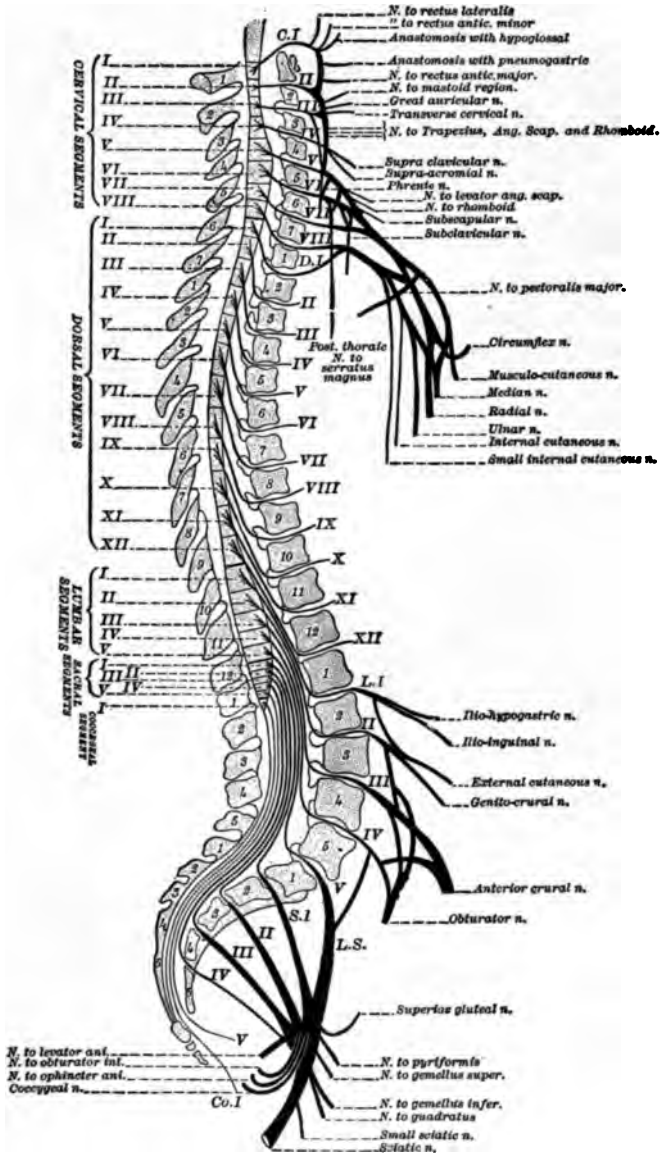

FIG. 7.—THE RELATIONS OF THE SEGMENTS OF THE SPINAL CORD AND THEIR NERVE ROOTS TO THE BODIES AND SPINES OF THE VERTEBRÆ. (Déjérine and Thomas, modified by Starr.)

cord. It is also seen after hemorrhage and in softening of the cord following thrombosis. Syphilis of the cord may produce a like paralysis of the lower extremities, as does primary lateral sclerosis.[1]

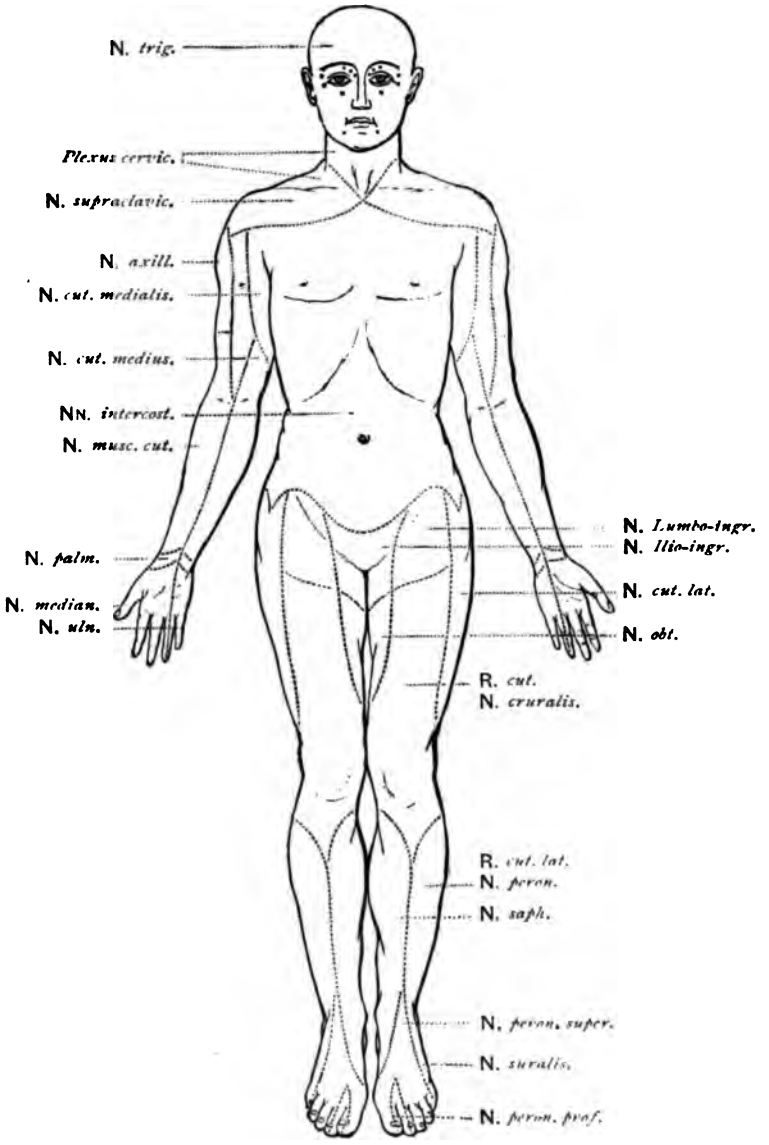

FIG. 8.— PERIPHERAL DISTRIBUTION OF THE SENSORY NERVES. (Bailey.)

Spino-muscular Paralysis (Peripheral Neuron Type).—The second, or spino-muscular, type of paralysis has the following characters: The muscles are

[1] Starr, *loc. cit.*, p. 170.

usually entirely paralyzed and recover slowly, if at all. All the muscles of a limb may be affected, but usually they are not; certain muscles are paralyzed, while others are not; or, if all are at first affected, some will recover

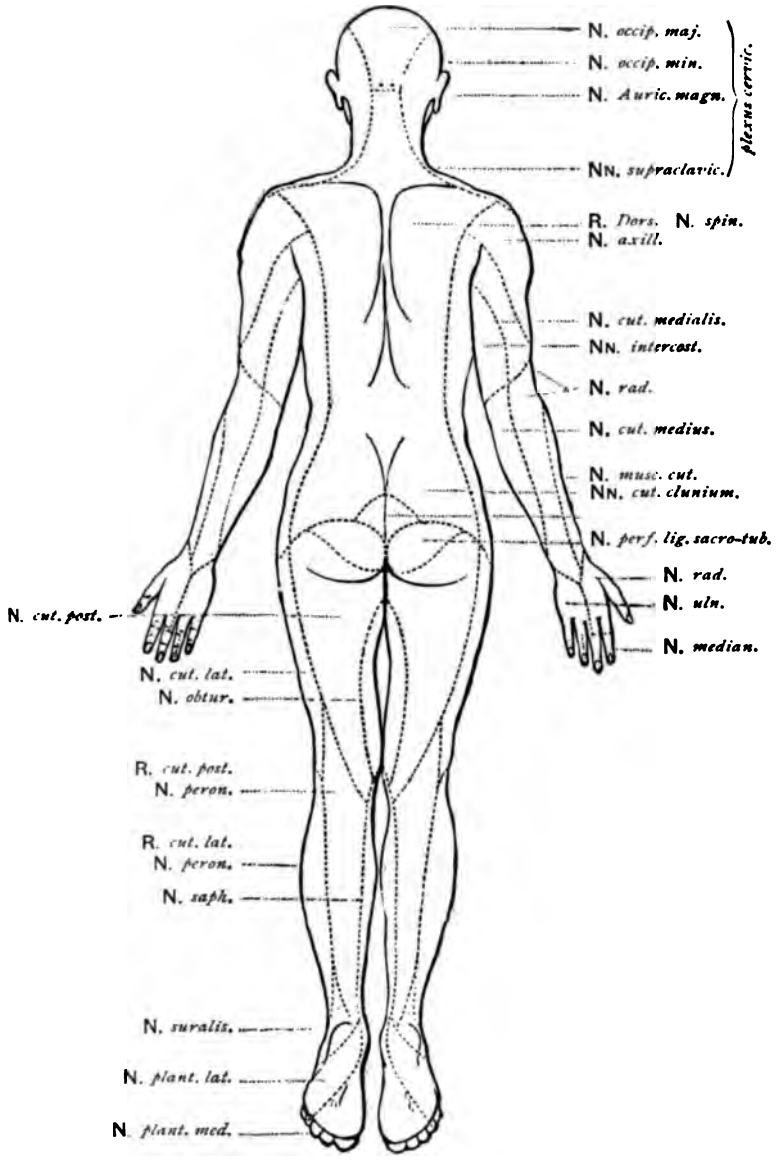

FIG. 9.—PERIPHERAL DISTRIBUTION OF THE SENSORY NERVES. (Bailey.)

much more completely than others. The limb is not rigid, but hangs loosely; the joints are not stiff, but are abnormally mobile. The muscles are relaxed and flabby. Tapping of the muscle or of its tendon is followed by no

contraction. The tendon reflexes are abolished. The muscles undergo early atrophy and soon exhibit the reaction of degeneration—that is to say, neither the faradic nor galvanic electrical current passed through the nerve of the muscle causes it to contract, and the faradic current passed through the muscle itself causes no contraction. The circulation of the limb is impaired, the limb is blue, its surface cold. Sensory disturbances may or may not be present.

As stated, this form of paralysis is due to a lesion of the motor cells in the anterior horns of the gray matter in the cord. It is seen in syringomyelia, in tumors and hemorrhages within the cord, in softening of the cord due to embolism and thrombosis, and in some forms of myelitis. It is seen in a number of those injuries and diseases of the cord not commonly regarded as amenable to surgical treatment, but it is quite important to differentiate this form from paralysis due to lesions of the peripheral nerves.[1] This is generally possible by observing the distribution of the paralysis; for the nerve fibers originating in each segment of the cord do not correspond in their distribution to the distribution of the individual peripheral nerves, and hence the paralysis following the lesion of a nerve trunk does not correspond in distribution with that originating in a segment of the cord.

Compare table showing the distribution of motor fibers arising in the different segments of the cord and diagram showing the relations of the segments of the spinal cord and their nerve roots to the bodies and spines of the vertebræ. (See pages 29 and 9.) By comparing these table and diagrams with the well-known distribution of the motor nerves it will be seen that lesions of a single spinal segment and of a single nerve trunk produce paralyses of muscles which are unlike.

For example, the deltoid muscle may be paralyzed alone from a lesion of the circumflex nerve, but is never paralyzed alone from a lesion of the cord. The extensors of the wrist and the supinator longus are paralyzed by division of the musculospiral nerve; such a combination does not occur from a lesion of any segment of the cord.[2]

Another means of differentiation between lesions of the cord and lesions of peripheral nerves is that in paralysis due to lesions of nerves anesthesia is usually an associated symptom. Anesthesia is absent in lesions of the cord involving merely the motor apparatus, or if anesthesia is present from a lesion of the cord its distribution will be different from that of the anesthesia due to a lesion of the nerve. These differences can be studied on the accompanying diagrams, which show the areas of cutaneous distribution of the sensory nerves arising from the segments of the cord and the cutaneous distribution of the several cutaneous nerves, respectively. (See Figs. 8, 9, and 10.)

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[1] Starr, *loc. cit.*, p. 171.

[2] *Ibid.*, p. 176.

General Characters of Paralysis Following Injuries and Diseases of the Spinal Cord.—Paralysis from injury of the spinal cord, such as follows fractures and dislocations of the vertebræ, appears, speaking broadly, in two forms—according as the cord is partially or entirely destroyed. It is very important to dis-

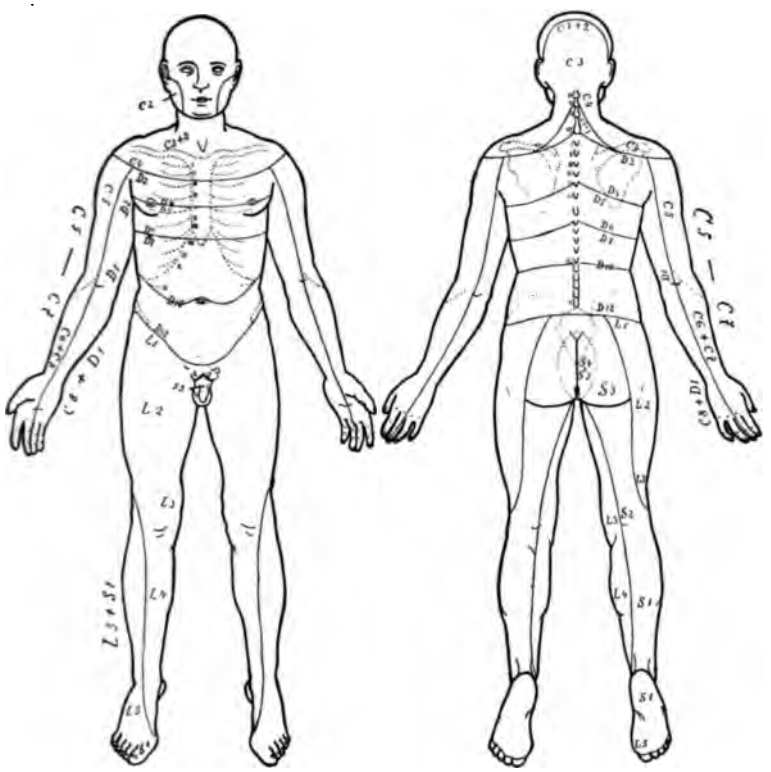


FIG. 10.—DIAGRAM SHOWING SENSORY NERVE SUPPLY OF THE SPINAL-CORD SEGMENTS. (Bailey, after Seiffer.)

tinguish clinically between these two forms, since, in the latter, operation is useless and unjustifiable. When, as the result of a transverse injury, the cord is compressed or contused, but not destroyed, there is total paralysis below the level of the injury, with a rigid condition of the muscles and increase of tendon reflexes. There is loss of control of the bladder, with either spontaneous evacuation or retention of urine. There is often some abdominal distention from paralysis of the wall of the gut (Thorburn, Kocher). See, however, Hematomyelia and other partial lesions. When the spinal cord is completely destroyed at any level there is absolute paralysis of the muscles below that level. The muscles are relaxed and not rigid (peripheral neuron type). There is total loss of muscle and tendon reflexes. The paralysis is symmetrical on the two sides of the body; there is retention of urine, there is vasomotor paralysis and congestion of the surface of the extremities, sometimes priapism. The genital reflex is increased (squeezing the testes causes contraction of the muscles

of the abdominal wall). There is loss of sensibility to pain and temperature, and usually to touch, at a definite level on the surface.[1]

Spasmodic Contraction of the Muscles

Spasmodic contraction of the muscles as the result of injuries and disease of the spinal cord occurs in two forms: (1) A general trembling of the limb observed in spastic rigid paralyses, due to lesions of the lateral columns of the cord, and not of the spino-muscular motor centers in the anterior horns of gray matter. Such tremblings may be very painful. (2) Fibrillary twitching of the individual muscular bundles. Such twitching may be elicited by tapping the muscle or exposing the surface to cold air. Its occurrence indicates a lesion of the motor cells controlling the muscle.[2]

Disturbances of Reflex Action

(1) Tendon reflexes. (2) Skin reflexes. (3) The automatic functions of the bladder and rectum.

1. **Tendon Reflexes.**—Tendon reflexes are produced by smartly tapping the tendon of a muscle near its insertion, thus causing a sudden contraction of the muscle. The table from Bailey [3] (see p. 32) indicates the most important muscular reflexes present in health, together with the spinal segments by which they are controlled. The loss of tendon reflexes, in the absence of lesions of the peripheral nerves, indicates a lesion of the spinal cord situated in that segment of the cord which presides over the particular reflex which is absent. Accordingly, the symptom becomes a valuable one in locating a lesion at a definite level in the cord. The tendon reflexes are abolished after destruction of the cord, in some cases of tumors and of hemorrhages into the cord, and in several diseases of the cord which impair the integrity of the posterior columns, notably in locomotor ataxia, in some cases of paresis, and in other nonsurgical diseases of the cord.

Exaggeration of the tendon reflexes indicates that the inhibitory action of the brain upon the cord, normally passing through the lateral columns of the motor tracts, has been interfered with. As the result of such interference the cord reacts more violently to sensory impulses, and then the phenomenon known as *clonus* can be observed—i. e., if the tendon of a muscle is suddenly put upon the stretch, a series of rapidly repeated contractions of the muscle are induced. Thus, if while the leg is supported the foot be grasped and suddenly pushed into a position of extreme dorsal flexion, the muscles of the calf of the leg may be felt to contract and the foot will exhibit a rapid series of vibrations (ankle clonus). A similar clonus may be observed in the quadriceps extensor cruris by placing the knee in the extended position, the muscles of the thigh being relaxed; if, then, the patella be suddenly crowded downward, thus

[1] Starr, *loc. cit.*, pp. 177–178. [2] *Ibid.*, p. 178. [3] Bailey, *loc. cit.*, p. 196.

putting the quadriceps tendon upon the stretch, the attached muscles will exhibit a series of contractions. Such phenomena may sometimes be observed in the elbow, wrist, and fingers. *A certain sign of disease in the lateral columns* of the cord or in *the motor tract* is known as Babinski's reflex. If the sole of the foot be scratched, the extensor muscle of the great toe is thrown into violent contraction, so that its tendon stands out prominently. This sign is absent in hysteria, and hence is a valuable diagnostic symptom, since other tendon reflexes may be increased in that disease.[1] Clonus is an indication of impaired function in the lateral columns of the cord, and appears early in cases where motor impulses—passing from the brain to the cord—are interfered with. It is commonly observed in Pott's disease when the cord is being pressed upon by the bones or its nutrition is impaired. The tendon reflexes may be *increased* in *pressure* upon or *partial* destruction of the cord from injury. After total destruction of the cord at any level the reflexes below that point are abolished. Although the explanation of this is not clear, nevertheless it is an important clinical distinction to bear in mind.

2. **Skin Reflexes.**—The skin reflexes (see table) are commonly lost in those diseases in which the tendon reflexes are increased. They are present in hysteria, absent in some diseases of the brain. They are far less important in diagnosis than the muscular reflexes.

LOCALIZATION OF SKIN REFLEXES IN THE SPINAL CORD (STARR) [2]

Reflex Acts.	*Localization in Segment.*
Epigastric reflex: Stroking breast causes dimpling of the epigastrium.	Seventh to ninth dorsal.
Cremasteric reflex: Stroking inner side of thigh causes retraction of scrotum.	First and second lumbar.
Gluteal reflex: Stroking buttock causes dimpling in the fold.	Fourth to fifth lumbar.

3. **Reflex Mechanisms Controlling the Bladder and Rectum.**—These are located in the fourth and fifth sacral segments of the cord. Their functions are of two kinds. Sensory impulses received in the cord from distention of the bladder and rectum cause a stimulation and contraction of the detrusor muscles and an inhibitory influence upon the vesical and anal sphincters such that these muscles relax, allowing the urine or feces to escape. In certain diseases (transverse myelitis of the dorsal region) these centers may be cut off from the controlling action of the brain, and usually continue to act automatically.[3] The bladder and rectum may empty themselves at proper intervals, but involuntarily; the condition is known as *active incontinence*. If, on the other hand, the centers in the sacral segments are destroyed, the bladder and rectum no longer empty themselves, except incompletely, by overdistention. When the

[1] Starr, *loc. cit.*, p. 181. [2] *Ibid.*, p. 182. [3] *Ibid.*, p. 183.

bladder becomes distended the resistance of the vesical sphincter may be overcome and the urine slowly dribble away—*passive incontinence of urine.* In other cases it is said that the bladder may actually burst from overdistention.

The rectum does not tend to empty itself unless the feces are semifluid. Disturbances of the bladder and rectum are very common in all injuries and many diseases of the spinal cord and constitute one of the gravest dangers of such conditions. Catheterization leads, sooner or later, to infection of the bladder, and finally an ascending infection passes up the ureters and invades and destroys the kidneys. The rectum may, of course, be emptied mechanically without danger, although such efforts are not always easily successful.

For the characteristic attitudes of patients after injuries of the spinal cord, see Injuries of Special Parts of the Cord.

Disturbances of Sensation

Irritation of the sensory areas of the cord may produce paresthesiæ—i. e., abnormal sensations referred to different areas of skin, or to entire limbs, or parts of limbs, corresponding in situation to the diseased centers in the cord; such sensations are of heat or cold, tingling, numbness, fullness, pressure, or weight.[1] Destruction of sensory areas in the cord leads to loss of sensation—*anesthesia.* Such anesthesia will be total if the sensory areas are entirely destroyed at any level, or if the posterior nerve roots are cut or destroyed. Such complete anesthesia also follows the division of a peripheral sensory nerve trunk. If the disease or injury of the sensory area in the cord is only partial, then some kinds of sensation may be lost, while others are retained. The sensory nerve fibers entering the cord by the sensory roots diverge, and pursue different paths to the brain; hence a lesion which involves some, but not all, of the sensory tracts of the cord may produce only an incomplete anesthesia. The different varieties of sensation are: ordinary tactile sensation or the sense of touch—its loss is known as tactile anesthesia; the sense of pain—its loss is known as analgesia. Sensations of temperature — its loss is thermo-anesthesia. The muscular sense—its loss produces imperfect muscular coördination or ataxia. A loss of tactile sensation due to a cord lesion implies a widespread degeneration or destruction in the antero-lateral and posterior columns of the cord. Analgesia and thermo-analgesia implies a lesion of the central gray matter and of the ascending antero-lateral fibers, *common in hematomyelia with preservation of tactile sense;* and a loss of muscular sense—ataxia—a lesion of the posterior columns of the cord. If the lesion of the cord is unilateral there is usually tactile anesthesia of the side of the body opposite to the lesion, together with some hyperesthesia of sensation upon the same side of the body as the lesion. The sensory impulses are believed to cross the cord and ascend to the brain in the columns of the opposite side. Total destruction of a segment of the cord at any level produces complete anesthesia of the entire body below the level

[1] Starr, *loc. cit.*, p. 187.

of the lesion. Careful study of the areas of anesthesia in any case of injury or disease of the spinal cord, and comparison with Fig. 10, which shows the areas of skin connected with each segment of the cord, will permit the injury to be located in the proper segment of the spinal cord.

The areas of skin supplied by the several segments of the cord overlap, each skin area being supplied by two adjacent segments of the cord. It is important to bear this fact in mind in locating the level of a lesion. For example, if anesthesia of the skin is observed extending upward as far as the upper level of the skin, supplied by any given segment, then it is certain that the next segment above is also involved. Further, abolition of function in a single segment will not produce anesthesia, sensation being still furnished by the segment above or below (Sherrington, Starr). It has been observed that division of a single posterior nerve root does not produce anesthesia. The level of the anesthesia is thus a most important guide in determining the level of the lesion in fractures and dislocations of the vertebræ, in hemorrhages into the cord, and in pressure upon the cord by tumors.

Small areas of anesthesia from small localized, not complete, transverse lesions of the cord are observed; chiefly in syringomyelia, in hemorrhages into the cord, in cases of pressure from tumor of the cord, or when small areas of softening are present (Starr). Such small lesions producing limited areas of anesthesia are not very frequent. The anesthetic areas fade off gradually in the normal sensation of the surrounding skin, thus differing from the anesthesia of hysteria in which the line of demarcation is much sharper. The determination of the exact limits and the distribution of anesthetic areas in the skin is a valuable diagnostic aid in differentiating lesions of the spinal cord itself from lesions of the nerve trunks, from lesions of the cauda equina, from hysteria, and from multiple neuritis. In lesions of the nerve trunks the distribution of the anesthesia differs from that observed after lesions of the segments of the spinal cord. This will be readily evident by comparing Fig. 10, showing the skin areas connected with the several segments of the spinal cord, with Figs. 8 and 9, showing the skin areas supplied with sensation by the different peripheral nerves.

FIG. 11.—THE MOST FREQUENT DISTRIBUTION OF HYSTERICAL ANESTHESIA. (Bailey.)

Hysterical anesthesia is to be differentiated from that due to lesions of the cord by the fact that in hysteria the genital organs, the anus, and the perineum are never anesthetic. The boundaries of the anesthetic area are, moreover, more sharply defined than is the case in cord lesions. Further, retention of urine is common in hysteria; actual paralysis of the bladder and rectum, with dribbling of urine, does not occur. The shapes of the anesthetic areas common in hysteria and their limits are quite different from those observed in lesions

of the cord. See Fig. 11, also Traumatic Hysteria. Of hysterical paralysis it is to be observed that the muscles do not show the reaction of degeneration, nor are the tendon reflexes abolished. In multiple neuritis the anesthetic areas assume a glove-shaped or stocking-shaped form on both limbs, and do not invade the trunk. In many cases of traumatic neuroses following injuries of the spine, and in so-called concussion of the spine, it has been observed that the anesthesia is of the hysterical type.

Ataxia

Disturbances of the muscular sense with loss of coördination in muscular movements is sometimes observed in cases of tumor within the cord, or in tumors of the meninges pressing upon the posterior columns of the cord, as well as in several distinctly nonsurgical affections of the cord, notably in posterior sclerosis (locomotor ataxia). The paths of the fibers controlling the muscular sense pass in the posterior external columns of the cord, or column of Burdach, and in the column of Goll (Starr).[1] The characteristics of the ataxic gait are: the steps are uncertain and of irregular length, the person tends to lose his balance as he walks and makes irregular efforts to save himself from falling. In rising from a chair he straddles widely and sways for a moment before stepping out. The forward step in advanced cases resembles a kick, the feet are far apart and are elevated far off the ground. Closing the eyes renders the ataxia more marked. It is quite impossible for a person with advanced locomotor ataxia to stand upright with the heels together and the eyes closed. The individual sways from side to side and would fall unless he opened his eyes or were supported. Normal individuals may sway slightly when they stand with the eyes closed, but never to this marked extent.

Pain in Injuries and Diseases of the Spine

Pain may be felt in the spine itself, or may be a referred pain. Pain referred to the spinal region indicates rather irritation of the posterior nerve roots or of the meninges, than of the cord itself. Such pain is also common in traumatic neurasthenia and in traumatic hysteria as well as in hysteria from other causes. Pain due to various diseases of the abdominal viscera may also be referred to the back. Diseases of the vertebræ, their ligaments, and of the nerve roots may also cause pain in the back. Pain due to injury or disease of the cord itself is caused by irritation or injury of the posterior nerve roots at their entrance to the cord, or to an irritation of the sensory nerve tracts as they ascend in the cord. Such pain is not felt in the spine but is referred to that portion of the body from which the affected nerve elements proceed. The location of the pain thus becomes of diagnostic value in locating the lesions of the cord. Compare figure showing sensory distribution of the spinal segments.

In injuries causing pressure upon or crushing of the cord, such as frac-

[1] Starr, *loc. cit.*, p. 196.

tures and dislocations of the vertebræ, in hemorrhages into the cord, and in cases where the cord is pressed upon by tumors, the pain is referred to the periphery below the level of the lesion. Thus, in a lesion of the lower cervical region a severe generalized pain may be felt in the entire body below the arms, and such pain may be made much worse by motion causing an increased pressure upon the cord.[1] (See also Tumors of the Vertebræ and Tumors of the Cord.) In tumors of the cord pain is one of the earliest and most pronounced symptoms. If the area of the cord compressed is small, a pain may be felt only in parts of the body connected with one or more nerve roots. If the tumor is in the dorsal region, such pain is sometimes felt in the thorax or abdomen. If the tumor is larger so that the sensory tracts are irritated, the pain may be referred to the body below the level of the tumor. In diseases of the nerve roots and in tumors of the spinal vertebræ, notably sarcoma and carcinoma, sometimes in caries of the spine, the function of the sensory nerve roots may be abolished, so that some portion of the integument is anesthetic, but the irritation of the fibers above the lesion may cause a pain referred to the anesthetic periphery—" anesthesia dolorosa."

Vasomotor and Trophic Disturbances

Vasomotor and trophic disturbances are common after injuries and in certain diseases of the cord—notably syringomyelia and locomotor ataxia. Injuries and diseases which destroy the cord are regularly followed by impaired circulation, blueness and coldness of the extremities, and by a diminished nutrition of the tissues. The muscles atrophy, the bones become fragile. In locomotor ataxia and syringomyelia there is a decided tendency to localized gangrenous processes, to destructive lesions of the joints following slight trauma or continuous pressure. Such lesions can be partly but not entirely explained by diminished sensibility and the consequent unobserved pressure upon bony prominences. The same may be said of the pressure sores—decubitus—after injuries of the cord. Probably both diminished nutrition and loss of sensibility are causative factors in these conditions. (See also Gangrene, vol. i, p. 213.)

INJURIES OF THE SPINAL CORD

It is important to bear in mind that the spinal cord is better protected against external violence than any other structure in the body. In rare cases the spinal cord may be injured by muscular violence; as when an individual diving into shallow water violently extends the head and neck in order to avoid striking the bottom. Other similar causes will be spoken of later. In the vast majority of instances the spinal cord is only injured by extreme degrees of violence transmitted to the spine itself. As Bailey has pointed out, slipping upon a banana peel, or the violence exerted upon the body by the sudden starting or

[1] Starr, *loc. cit.*, p. 197.

stopping of a railway train, are not sufficient to cause injuries of the spinal cord. Usually the cord is injured by falls from a height upon the head, or upon the buttocks, by blows or falls upon the spine such that the spine is violently bent or twisted, causing a rupture of the muscles and ligaments which hold the vertebræ together; and often in addition fracture of one or more of the vertebræ. Among the commonest causes of fracture of the spine are violent twists or wrenches which fracture or dislocate the vertebræ, or tear the spinal ligaments and cause compression, or contusion, or laceration of the cord through the medium of the displaced bones. Stab and gunshot wounds may also injure the cord. Injuries to the spinal cord are relatively infrequent; thus, among 70,000 general injuries tabulated by Wagner and Stolper, only 0.71 per cent involved the spinal column. The cord escapes in about one third of the cases of injury to the spine.

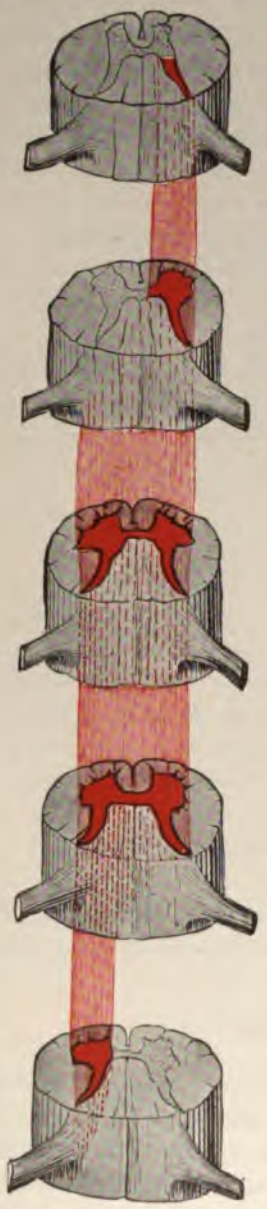


FIG. 12.—DIAGRAM TO ILLUSTRATE THE COURSE OF THE BLOOD IN A CASE OF HEMATOMYELIA. (Bailey.)

PATHOLOGY

Injuries of the membranes of the cord are rarely attended by definite symptoms apart from those accompanying the commonly associated injuries of the cord itself. The dura and pia may be torn or contused with resulting hemorrhage, either epidural or subdural and extramedullary. Such bleeding may form extensive clots. The condition as such cannot be recognized clinically, and is usually associated with fracture of the vertebræ and with serious injury of the cord (Bailey).

Contusion and Laceration of the Cord.—Contusion and laceration of the cord may produce partial or total destruction of its substance. The lesions are commonly described as total transverse lesions and as partial lesions respectively, or, clinically, as "severe and partial lesions" (Bailey). It is almost certain that if the nervous conducting fibers of the cord are completely divided or crushed they never regenerate.

Hematomyelia.—Hemorrhage into the cord is a regular accompaniment of severe contusions of its substance. It may also occur as an independent lesion

without discoverable injury to the bones. In the latter group the dorsal and ventral horns of gray matter are the common sites of hemorrhage. The blood finds its way up and down the cord, often through two or more segments. Sometimes on one side of the medium commissure, sometimes on both. The extension upward is usually further than that downward (Bailey). (See Fig. 12.)

The symptoms produced are focal. Usually the hemorrhage is confined to the horns of the gray matter, though in the more severe cases the lateral white columns may be invaded. In other cases, minute or larger hemorrhages into the white columns are observed. The destruction of the cord varies with the extent of the hemorrhage. In some cases a considerable cavity is formed filled with blood clot surrounded by more or less extensive areas of softening. When the latter is absorbed a cavity remains in the cord resembling in appearance the cavities seen in syringomyelia, and since the symptoms produced may simulate those observed in the latter disease, the condition is sometimes spoken of as "Traumatic Syringomyelia." The most frequent site of localized hemorrhages into the cord is the region where the greatest mobility of the spine exists—namely, in the *lower cervical region corresponding to the fifth, sixth, seventh, and eighth cervical and first and second dorsal segments* (Bailey).

It is possible also that primary traumatic hematomyelia occurs in the lower lumbar region and in the conus medullaris. In the majority of the cases of hemorrhage in this region, however, there have been serious lesions in the bones. In some few cases of fracture of the spine in the lower dorsal and lumbar regions there appear, in addition to the symptoms of more or less complete paralysis of the legs, evidences of a partial lesion in the cervical region, although the cervical vertebræ remain intact. Such cases can best be explained by primary hematomyelia in the cervical region, due to forced movement in the neck, without fracture, which occurred at the same time as the fracture in the lower region. A disseminated type of hematomyelia, consisting of minute punctate hemorrhages throughout the entire length of the cord, has been observed at autopsy after severe general traumata. The hemorrhages are minute, many of them too small to be seen by the naked eye. Clinically these lesions cannot be recognized with certainty.[1]

Causation and Mode of Production of Injuries of the Spinal Cord

In fractures and dislocations of the spinal column the bones may be displaced in such a way that the spinal canal is suddenly narrowed and the cord compressed, crushed, contused, or torn. The injury is in most cases of momentary production. The displaced bones after the force has ceased to act spring more or less completely back into place. The cord may be completely crushed or cut in two, or in other cases more or less severely lacerated. The hemorrhage in severe lesions of the cord is usually a matter of secondary importance.

In other less severe cases the canal is but slightly narrowed and the cord

[1] Bailey, *loc. cit.*, pp. 168–169.

escapes with a slight or moderate contusion. In about one third of the cases of fractures and dislocations the cord escapes injury. Except in the case of gunshot wounds, loose fragments of bone are rarely present. The effects of bullet and stab wounds upon the cord resemble those produced by fractures and dislocations. The bullet, or the blade, or a splintered bone fragment produce contusions and lacerations and hemorrhage. The lesions produced are usually partial (Brown-Séquard Paralysis). In open wounds involving the cord the added danger of infection is always present. In addition to the actual destruction of the cord there is usually marked contusion, and hematomyelia is often present (Bailey).

Distortion.—Stretching of the cord without demonstrable lesion of the spine occurs only in the cervical region and results from sudden forcible flexion or extension of the neck.

The mechanism of production consists in the cord being actually stretched so that its component parts are torn in their long axes, or in the cord being drawn too tightly over the posterior surface of the body of a vertebra or of a vertebral disc. This variety of injury is most frequent in the region of the fifth and sixth cervical vertebræ, and is particularly effective in causing hemorrhage. It is impossible to conceive the blood-vessels of the spinal cord being torn without the nerve fibers being injured also, yet in many of the cases the hemorrhage is undoubtedly the most important lesion. Distortion may also cause laceration of the cord without hemorrhage.[1]

Hemorrhage is so important a part of the lesion produced by distortion that it constitutes a well-defined group of spinal-cord injuries.

General Symptoms of Spinal-cord Injuries

Since the injuries which produce lesions of the spinal cord are severe and generalized, concussion of the brain and shock are not infrequently present. As in other severe traumata the symptoms of concussion may last for minutes or hours; the symptoms of shock may persist until death or may be gradually recovered from after a variable interval.

Motor Symptoms.—The paralysis following injury to the spinal cord comes on instantly in most cases.

The patient may receive a severe general injury and be found unconscious and paralyzed. In other cases he receives an injury, falls, and finds himself unable to use his legs. In rare cases he is still able to walk after the injury, though with difficulty. In a few hours the weakness in the legs rapidly increases until the patient is entirely paraplegic. In this last group of cases a moderate contusion has occurred followed by a destructive hemorrhage. In other cases a slight paralysis becomes complete when the patient is moved. Here a partial lesion of the cord has been rendered complete by the movement of the displaced bones.[2]

[1] Bailey, *loc. cit.*, p. 173.

[2] *Ibid.*, p. 174.

In these cases, if the injury is in the cervical region above the region of the phrenic nerve, the attempt to move the patient may be followed by instant death.

In excessively rare cases the paralysis is slight at first and rapidly improves, so that the patient is able to be up and about again. But after a few weeks the muscular power begins again to disappear from the parts originally affected, and the patient goes on with symptoms of slow compression.[1]

The extent of paralysis after injuries of the cord varies. In severe injuries the patient becomes immediately paraplegic and remains so until death. In many cases the extensors are more completely paralyzed than the flexors, so that the patients are able to flex the fingers and toes slightly immediately or soon after the accident. In partial lesions the paralysis may be complete at first, but may soon improve. In slight cases the paralysis is incomplete from the first and amounts merely to weakness of the affected muscles. The distribution of the paralysis varies. In cervical lesions involving both sides of the cord all four extremities are paralyzed (paraplegia). Similar lesions in the dorsal region produce paralysis of both legs. In partial lesions, though all the muscles are weakened below the injured segments, the paralysis may chiefly involve the arm and leg of one side of the body (spinal hemiplegia—Brown-Séquard Paralysis). In other cases but one extremity may be involved (monoplegia), or both arms (diplegia brachialis). The character of the paralysis varies with the situation and severity of the lesion. Injuries of the lower lumbar and sacral regions, whether slight or severe, are followed by flaccid paralysis. Early atrophy of the muscles and electrical reaction of degeneration follows (peripheral neuron type—spino-muscular paralysis—Bailey). In the upper lumbar region the paralysis is at first flaccid. Later on it may show a combination of central and peripheral neuron types. In the dorsal region the central neuron type is regularly present. In the cervical region the peripheral neuron type occurs in the hands and arms, the central neuron type in the lower extremities. Extensive lesions produce flaccid paralysis, with total loss of reflexes. When the lesion is partial, so that the flexors are not completely paralyzed, and during recovery, when the flexors regain more power than the extensors, contractures are common. The limbs often become permanently and helplessly flexed. Evidences of irritation are often observed both in muscles completely paralyzed as well as in those only weakened. The affected muscles frequently undergo spasmodic contractions, so that the legs twitch and jerk. These symptoms are observed chiefly at night. Fibrillary tremors are also observed in the paralyzed muscles.

Sensory Symptoms.—The sensory symptoms after spinal-cord injuries are pain, hyperesthesia, paresthesia, and anesthesia.

Pain.—There may be local pain, due to the injury of the bones, muscles, and ligaments of the back; or it may be radiating, and is then due to irritation

[1] Bailey, *loc. cit.*, p. 174.

of the posterior nerve roots. Local pain is present in some cases, absent in others. If present it is constant, rendered worse by movement, and is of a dull, aching character. In nearly every case of spinal-cord injury there is marked local tenderness over the spines of the vertebræ in the affected region, most marked over the spine of a single vertebra in the majority of cases. Radiating pains are present in partial lesions, absent in total lesions. Such pains are severe and lancinating. They are more marked in the arms than in the legs and are excited by movements of the spine and extremities. They may be the most prominent symptoms of partial lesions of the cord. Soon after the accident they may be very severe, but later diminish and finally disappear.

Hyperesthesia and Paresthesia.—Hyperesthesia and paresthesia are commonly associated with anesthesia.

Thus, when cutaneous sensibility is impaired, rather than lost, as in cases of partial lesions or in recovery from total anesthesia, hyperesthesia and paresthesia are often prominent. It is a very good index that recovery has begun when patients who have been deeply anesthetic complain of numbness, tingling, and pain to touch in the affected parts. In severe lesions there is often a zone of hyperesthesia directly above the total anesthesia. Subjectively this may be complained of as a girdle sensation.[1]

In severe lesions of the cord, anesthesia is marked from the first, and persists, involving all forms of cutaneous sensibility. In partial lesions, though usually present to a greater or less degree, it may be absent or may exist as a diminution of cutaneous sensibility merely. The distribution of anesthesia corresponds with the distribution of the affected segments of the cord. Bailey considers that *hyperesthesia,* if found in characteristic areas and associated with other symptoms, is as valuable for diagnosis as anesthesia.

Elective Anesthesia.—Elective anesthesia is produced almost exclusively in lesions in the central part of the cord. The normal sense of touch is preserved, while the temperature sense and the pain sense are diminished or lost. In the cases where ordinary tactile sensibility is interfered with there will nearly always be also diminution or loss of the temperature sense and the sense of pain. Elective anesthesia may be found over a narrow area, just above the limit of total anesthesia. It indicates hemorrhage in the cord above the seat of the total lesion (Bailey). Anesthesia is a symptom which in partial lesions does not exist as long as paralysis. In many cases, though it begins suddenly, it soon improves. If the patient is to recover, the area of total anesthesia diminishes and may finally disappear. If no improvement in anesthesia occurs during the days and weeks following injury, its persistence is of bad significance.

Reflexes.—When a lesion involves the region of the cord in which a reflex center is situated, as, for example, the lumbar region, the center for the knee-jerk, the reflex is diminished or abolished according to the severity of the lesion. When,

[1] Bailey, *loc. cit.*, p. 176.

however, the cord is involved higher up, the behavior of the reflexes whose centers are lower down is variable. The clinically important reflexes are the plantar and the knee-jerk. The behavior of the abdominal reflexes is variable and uncertain. The cremasteric reflex is diminished or lost only, never exaggerated, and then only when its center is involved. The plantar reflex—namely, flexion of the great toe on tickling the sole of the foot—is abolished in lesions of the sacral region. In lesions situated higher up it is inverted, becoming the Babinski phenomenon (i. e., a sudden extension of the great toe produced by scratching the sole of the foot, so that the extensor tendon stands out prominently). The knee-jerk is diminished or lost in injury to the second and third lumbar segments or their roots. But the behavior of the knee-jerk in lesions situated above these segments varies with the extent of the injury and with the time after the accident. Very slight injuries in the dorsal and cervical regions may cause an exaggeration of the knee-jerk with foot clonus immediately. In more severe lesions in these regions the knee-jerk is diminished or abolished at first, to become exaggerated later. The jerk may be absent for weeks or even months, and then return and become exaggerated. The longer it remains absent, the more severe is the lesion. In extensive lesions, as in total transection of the cord in the dorsal and cervical regions, it is lost immediately after the accident. But even in such cases with complete division of the cord, the knee-jerk may return after a number of weeks, if the patient live so long. It is important to bear in mind that absence of the knee-jerk cannot of itself be construed as evidence of a complete transverse lesion.[1]

Genito-urinary Symptoms.—The most important genito-urinary symptom common in nearly all serious injuries of the spinal cord, and even in those which are slight, is interference with urination. Retention of urine is one of the most constant symptoms of all injuries of the spinal cord. The patient is generally unconscious of the distended condition of the bladder and there is rarely pain. After the distention has reached a certain stage there is commonly constant dribbling of urine. When, with paralysis and anesthesia, the patient is still able to empty his bladder, it is a sign that the lesion in the cord is not severe. In rare cases of lesions situated very low down in the cord retention of urine may be the sole symptom. In most of the cases catheterization is unavoidable and the conditions are in every way favorable for infection. Some of these patients may be catheterized for weeks or months before infection of the bladder occurs, but, sooner or later, such infection is almost sure to take place. The patients develop an ammoniacal cystitis. There is a strong tendency toward an ascending infection and pyelonephritis, with a fatal result. In some cases phosphatic calculi develop in the bladder or in the pelvis of the ureter. In other cases the infection invades the tissues throughout the thickness of the bladder wall, with the production of pericystitis and the formation of abscess. In a few cases gangrene of the bladder occurs. Priapism is common in severe lesions and in high lesions, notably in young persons, soon after the injury.

[1] Bailey, *loc. cit.*, p. 178.

Trophic and Vasomotor Disturbances.—Following injuries to the spinal cord a rise of bodily temperature is common immediately after the accident, or after a few hours. In lesions of moderate severity the temperature rarely rises above 101° F., and in general the higher the temperature the worse the prognosis. In severe lesions of the cervical region very high temperatures are observed. They are of bad significance. In one case seen by me some years ago of a young man who had a fracture dislocation of the fifth and sixth cervical vertebræ from a fall out of a tree, the temperature rose soon after the accident to 106° F., and to 110° F. shortly before death, which occurred forty-eight hours after the accident. Such temperatures following severe injuries to the cervical cord are not unusual. During the later stages elevations of temperature are observed as the result of infection of the genito-urinary tract and in the presence of extensive bed-sores. A complicating pneumonia is also accompanied by fever.

The nutrition of paralyzed limbs is usually impaired, the skin often becomes dry and scaly, the growth of the nails is interfered with. Although soon after the accident the temperature of a paralyzed limb may be slightly elevated, later on such limbs usually become blue and cold.

Bed-sores (*Decubitus*).—One of the most serious and fatal complications following a severe injury to the spinal cord is decubitus, or bed-sore. In serious lesions they may appear very suddenly, soon after the accident, and in twenty-four hours may be well developed. The bed-sores appear upon the parts of the body the seat of pressure; the most frequent site is upon the buttocks and over the convexity of the sacrum. They also appear upon the heels, and in cervical lesions upon the elbows and shoulder-blades. I have a case of fractured spine now under my care who has a large bed-sore of the calf of one leg. The skin which is pressed upon becomes slightly reddened; the redness extends in a more or less circular form and becomes dark red or purple. Blebs form upon the surface, and beneath them the skin undergoes a rapid necrosis. When the skin sloughs are removed the underlying tissues are found in a condition of moist gangrene, and frequently the bone underneath is necrotic (see also Gangrene). Bed-sores are one of the most frequent causes of a fatal result in serious injuries of the spinal cord.

Symptoms Referable to the Digestive Tract.—In injuries of the spinal cord there are usually no symptoms referable to the stomach. A most serious and distressing symptom in serious lesions is distention of the intestine by gas. This does not occur in injuries to the lumbar and sacral cord, but in higher lesions it is quite common. It is due to paralysis of the intestinal wall, caused by the loss of function of the sympathetic nerves of the abdomen. It usually does not make its appearance until some hours after the accident. It may last for some days and then disappear, or persist until death. Its importance and gravity depend largely upon the fact that the distention of the bowel interferes with respiration.

Constipation or, on the other hand, incontinence of feces are common after injuries of the spinal cord. In partial lesions constipation may be marked.

In more severe lesions incontinence of feces is the rule. The sphincter muscle is paralyzed, and the feces escape from the bowel without the patient's knowledge. Paralysis of the sphincter is readily recognized by inserting the finger through the anus. The muscle does not grasp the finger, and when the finger is withdrawn the anus remains patent. In some cases instead of incontinence, if the bowels are costive, there may be persistent constipation, only to be relieved mechanically.

There is nothing characteristic about the pulse-rate in injuries of the spinal cord. Immediately after the accident the pulse is accelerated. Later on it may return to normal, but is often intermittent. Following infection of any sort there is a corresponding acceleration of the pulse-rate. The respiration may be interfered with in high lesions by paralysis of the muscles of respiration and by the distention of the abdomen with gas. In the cases which are doing badly congestion and edema of the lungs are common and are frequent causes of death.

Focal Diagnosis of Injuries of the Spinal Cord

The surgical signs of fractures and dislocations of the spinal column resemble those of similar injuries to the bones in other parts of the body, but are often not easy to make out. Displacements are less marked in fractures than in dislocations, and the spinal cord itself may be severely injured without any apparent deformity of the bones. In combinations of fractures and dislocations the deformity may be quite marked. There may be a very distinct hump or projection of the spines of the vertebræ at the site of the injury, and in the cervical region there may be marked deformity of the head and neck. The head may be bent forward or turned to one side. It is sometimes possible to appreciate the projection of the body of a dislocated vertebra by palpation of the posterior wall of the pharynx. At the junction of the dorsal and lumbar regions the deformity in fracture dislocations may be quite marked. There may be a very prominent projection of one or more of the spines of the vertebræ, commonly the last dorsal or the first lumbar. The overlying parts may be the seat of swelling; there may be a distinct tumor formed in the skin and subcutaneous

Fig. 13. — Forward Dislocation of the Sixth Cervical Vertebra. No spinal-cord symptoms. (New York Hospital collection. Service of Dr. F. H. Markoe.)

tissues, caused by infiltration with bloody serum. Crepitation is a sign which may sometimes be observed in fractures of the spinous processes. It is a sign sometimes observed by the patient himself in fractures of the bodies and arches of the vertebræ when he is moved. This sign is rarely observed by the surgeon, except in isolated fractures of the spinous processes or of the laminæ. The X-rays are sometimes a very useful aid in the diagnosis of fractures and dislocations of the vertebræ; they are especially useful in locating bullets in the vicinity of the spine, or in detecting the presence of projecting bony fragments which may be pressing upon the cord. In the cervical region the X-rays are particularly useful, since it is possible here to get an excellent lateral view of the spinal column with the plate quite close to the bones. (See Fig. 13.) With good technic it is also possible to get satisfactory pictures of the dorsal and lumbar vertebræ, though here the difficulties are much greater. (See Fig. 14.) Stereoscopic pictures of the spinal column are very valuable for the detection of the presence and character of bony displacements; for, as already pointed out in the chapter on the X-rays, stereoscopic pictures, even if not of very good quality, may nevertheless give a more correct idea of the deformity than single pictures showing much more detail.

FIG. 14.—FRACTURE DISLOCATION OF THE LAST DORSAL VERTEBRA. Total paraplegia below the waist line; paralysis of the bladder and rectum. The injury was complicated by a rupture of the quadriceps extensor tendon upon the right side and fracture of both bones of the forearm upon the same side. The patient developed cystitis, pyelitis and bed-sores and had pneumonia, from all of which injuries and diseases he died nearly one year after the accident, pyemic. (Author's service, New York Hospital.)

Ecchymosis is an inconstant sign; it usually appears late, if at all, and is only frequent in injuries due to direct violence. The diagnostic signs of fracture will be spoken of more particularly under the fractures of special vertebræ. They are rarely of very great importance, since it is the injury to the spinal cord, rather than to the bones, which is the important element in the case.

Neurological Focal Signs.—The signs and symptoms due to the injury of the cord itself are more important and more reliable than the signs of injury to

the bones, since the former indicate the situation of the injury to the cord, while the latter merely indicate the relatively unimportant injury to the vertebræ, and the two may not coincide anatomically. It often happens that the most serious injury to the cord is situated several inches above or below the externally apparent injury to the spinal column. In order to diagnosticate the anatomical site of the injury to the cord it is necessary to know the relations between the vertebræ and the several segments of the cord. These relations have already been mentioned and are fully indicated in Fig. 7. The important neurological focal signs are: paralysis of the muscles, anesthesia, and disturbances of the reflexes.

Paralysis.—As already indicated, each segment of the spinal cord contains motor nuclei for more than one muscle, and no single segment contains all the nuclei for any muscle. Thus, each muscle is represented in at least two segments, and some muscles have nuclei in a number of segments. These facts at once serve as a means of differentiation between injuries of a spinal segment and injuries of a peripheral nerve (Bailey). It is impossible to have an injury of the spinal cord followed by paralysis of one single muscle. Several muscles, or groups of muscles, are always involved. On the other hand, the division of a nerve trunk may cause paralysis in one single muscle, and, as already indicated, the distribution of the paralysis, following injuries to nerves, is quite different from that following injuries to spinal segments. The following table, representing approximately the distribution of the several spinal segments to different groups of muscles is taken from Bailey's "Diseases of the Nervous System," etc.: [1]

Segments.	Muscles.	Segments.	Muscles.
C. ii-iii.	Trapezius.	C. vi.	Biceps.
	Sternomastoid.		Brachialis anticus.
	Levator anguli scapulæ.		Pectoralis major (clavicular part).
	Deep muscles of neck.		Serratus magnus.
			Triceps (?).
C. iv.	Diaphragm.		Extensors of wrist and fingers.
	Supraspinatus.		Pronators.
	Infraspinatus.		
	Deltoid.	C. vii.	Triceps.
	Biceps.		Extensors of wrist and fingers.
	Supinator longus.		Flexors of the wrist (?).
	Rhomboids.		Pronators.
	Scaleni.		Pectoralis major (sternocostal part).
C. v.	Supraspinatus.		Subscapularis.
	Infraspinatus.		Latissimus dorsi.
	Deltoid.		Teres major.
	Biceps.		
	Supinators.	C. viii.	Flexors of wrist and fingers.
	Pectoralis major (clavicular part).		Interossei.
	Serratus magnus.		Extensors of thumb (?).
	Rhomboids.		
	Scaleni.	D. i.	Extensors of thumb.
	Brachialis anticus.		Interossei.
	Teres minor.		Thenar and hypothenar muscles.

[1] Bailey, *loc. cit.*, p. 190.

Segments.	Muscles.	Segments.	Muscles.
D. ii.	Intercostals. Muscles of abdomen and back. Erectors of the spine.	L. v–S. i.	Flexors of knee. Glutei. External rotators of thigh. Long flexors of foot and toes. Peronei.
L. i.	Abdominal muscles. Iliopsoas. Cremaster. Sartorius.	S. i–ii.	Calf muscles. Peronei. Small muscles of foot. Erector penis (S. ii, Müller).
L. ii–iii.	Flexors and adductors of thigh. Sartorius (?).	S. iii–iv.	Perineal muscles. Ejaculator muscles (S. iii, Müller). Bladder. Rectum.
L. iii–iv.	Extensors and adductors of thigh. Abductors of the thigh. Quadriceps femoris. Tibialis anticus.	S. v.	Levator ani. Sphincter ani.

As already stated, the paralysis of muscles due to injury of their motor nuclei is of the peripheral neuron type. Severe injuries of the spinal cord above the fourth cervical segment are immediately fatal from paralysis of the phrenic nerve and diaphragm.

Anesthesia.—The extent and character of the anesthesia furnish the most certain data for the focal diagnosis of injuries of the spinal cord. Complete destruction of any segment causes total anesthesia of all parts at the level of and below that segment. The construction of diagrams indicating the sensory supply of the integument from the different spinal segments has occupied many observers. They vary somewhat in detail on account of the practical difficulties in the way of confirmation. Autopsies and microscopical examinations of the injured cords, together with careful clinical observances upon the living patient, are rarely complete, and, moreover, the functions of the different segments sometimes overlap a little, and, furthermore, the lowermost segments of the spinal cord are crowded into a very small space, so that accurate differentiation becomes difficult. The diagrams elaborated by Seiffer are as useful as any. They are represented in Fig. 10, and with them I give their interpretation as stated by Bailey.

Bilateral lesions of the spinal cord above, and involving the fourth cervical segment, are immediately fatal. Consequently the limits of anesthesia due to injury to segments above the fifth is obtained from one-sided affections. Anesthetic areas of these regions are indicated in the diagram. Below the lower boundary of the sensory area, supplied by the fourth cervical segment, the cutaneous surface is divided by Seiffer's scheme into districts. The lines which divide these districts form the basis of orientation for the individual segments. These lines are:

1. The neck-trunk line.
2 and 3. The axial lines of the arms (ventral and dorsal).
4. The intermammillary line.
5. The xiphoid line.
6. The umbilical line.
7. The trunk-legs line.
8. The sacral circle.
9 and 10. The axial lines of the legs (ventral and dorsal).

The Neck-trunk Line.—In front, this line runs across the chest, chiefly in the second intercostal space, with a slight convexity downward. It passes up over the upper part of the deltoid, so that the ventral axial line of the arm is perpendicular to it. This line is of especial importance in front, as there it constitutes the upper limit of anesthesia in lesions of no fewer than five segments—viz., C. v, vi, vii, viii, and D. i. After destruction of any one of these segments the upper limit of anesthesia in front is always the same, and corresponds with the neck-trunk line. Diagnosis as to which of these five segments is affected, cannot be made from the trunk anesthesia in front. On the back and the back of the neck the sensory distribution of the above-mentioned segments, while not quite so uniform as on the chest, still presents only slight variations. From the upper part of the deltoid the neck-trunk line passes backward, and then splits into two branches, the upper one ascending sharply to the fifth cervical spinous process, the other branch going to the spinous process of the seventh cervical vertebra. The line before its division, and its lower branch, form the upper boundary of the second dorsal segment, the lower boundary of the fourth cervical segment being formed by the line before its division and by its upper branch. In the small pyramidal space included by the branches of the lines from the two sides are to be found the sensory supply of segments C. v, vi, vii, viii, and D. i. Since the superior limit of anesthesia caused by injury to any of these segments is the same in front, and since it varies so little behind, diagnosis as to the particular one of these segments affected depends upon the distribution of anesthesia in the arms.

The axial lines of the arms give the key to the differential diagnosis of the segmental functions which are so closely packed together about the neck-trunk line. These lines run down the middle of the arm, one on the ventral, the other on the dorsal side. The part of the cutaneous surface lying external or radial to them is supplied by segments C. v, vi, and vii; that lying internal or ulnar to them, by C. viii and D. i.

The fifth cervical segment supplies a greave-shaped area on the outer side of the upper arm, the sixth cervical a similar area on the outer forearm. The first dorsal segment has a greave-shaped area along the ulnar side of both arm and forearm. Segments C. vii and viii must occupy positions midway between the preceding. For none of these can more definite boundaries be laid down, and except for the general line of division, as indicated in the figure, we are not in a position to give the segmental supply of the fingers.

The Intermammillary Line.—This line, extending between the nipples, marks the boundary between the fourth and fifth dorsal segments. Parallel to it and passing through the tip of the xiphoid process, is

The Xiphoid Line.—Between this and the preceding are contained segments D. v and vi, and below this line are collected, in order from above downward, D. vii, viii, and ix.

The umbilical line, passing with slight undulation around the body at the level of the umbilicus, is about the level of D. x. The remainder of the dorsal region is contained between it and the next line, called

The Trunk-leg Line.—This line in front corresponds with the inguinal fold. Behind, it runs nearly horizontal, passing back below the crest of the ilium. It forms the natural boundary between the trunk and the extremities, and marks the end of the dorsal region and the beginning of the lumbar. It is somewhat analo-

gous to the neck-trunk line in that it, in the middle of the body behind, marks the upper limit of a number of segments—viz., L. i, ii, iii, iv, and v, and S. i and ii. These segments, with the exception of the part of the trunk-leg line mentioned, have different superior boundaries, and are also to be further differentiated by the axial lines of the lower extremities.

The Axial Lines of the Lower Extremities.—These lines are similar to those of the upper extremities, except that they do not run in the middle of the limb. The dorsal axial line begins at the middle line of the body in the anal region, passing down the back of the leg behind the internal malleolus to the inner border of the foot. The ventral, or anterior axial line, is also posterior at first. Starting from the junction of the middle and outer third of the trunk-legs line, it passes over the middle of the gluteal region down the back of the thigh to just above the knee. It here becomes anterior, descending the leg in a slight sacral curve, passing beneath the lower border of the patella, gaining the tibial ridge, and then passing to the inner border of the foot, about the base of the great toe.

It is even more difficult to define exact sensory areas in the lower extremities than in the upper. This is in large part due to the close proximity which both lumbar and sacral segments have to each other, thereby making lesions closely confined to one segment unusual.

S. i, ii, and iii occupy the posterior part of the lower extremity contained between the axial lines. These areas are measured from above downward. Thus S. iii has its superior boundary in the trunk-legs line and in the boundaries of S. iv and v (to be immediately described). Below it is S. ii. Thus both of these are posterior, except that S. iii supplies the anterior part of the genitals, below the part supplied by L. i. S. i forms the transition between the lumbar and sacral regions. It is to be sought on the sole of the foot (perhaps somewhat above it posteriorly), and it may extend outward to the external part of the calf of the leg. L. i, ii, iii, iv, and v occupy the anterior surface of the lower extremity, the anterior axial line dividing L. iv from L. v and such part of L. i as may reach in front. Posteriorly, the lumbar segments occupy the regions not occupied by the sacral. L. v probably has a representation on the sole of the foot.

S. iv and v are contained in a saddle, or circle-shaped area of somewhat uncertain size, situated at the caudal extremity of the trunk.

Reflexes.—The changes in the various reflexes after injuries of the spinal cord have been sufficiently indicated elsewhere. The location of the most important reflexes is indicated in the following table (Bailey, p. 196):

Segments.	Reflexes.	Segments.	Reflexes.
C. v–vi.	Biceps. Supinator longus.	D. ix–xii.	Abdominal.
		L. i–ii.	Cremasteric.
C. vi.	Triceps.	L. ii–iii–iv.	Knee-jerk.
C. vi–viii.	Extension of wrist.	L. iv–v.	Gluteal.
		S. i–iii.	Foot clonus.
D. vii–ix.	Epigastric.		Babinski (plantar).

Brown-Séquard Paralysis.—Lesions involving half of the transverse section of the cord merely are attended by a group of symptoms known as Brown-Séquard paralysis. Such injuries occur as the result of stab and gunshot wounds of the cord, and occasionally from ordinary fractures in the cervical and dorsal regions. The symptoms are a crossed paralysis of motion and sensation. The following brief description is quoted from Bailey:

There is on the side of the injury paralysis with (usually) increased tendon reflexes. Loss of muscular sense (sense of position). Hyperesthesia, often higher than the anesthesia of the opposite side. On the opposite side, anesthesia. The anesthesia never includes the sense of position. It is frequently also elective, the pain and temperature sense being alone affected, tactile sensibility remaining normal. There is some reason to suppose that unilateral lesions in the sacral, and possibly in the lower lumbar region, give a slightly different picture. From a case of his own and from two earlier reported cases, Weisenberg believes that in these regions a one-sided lesion causes disturbances of motion and sensation in the lower extremity, external genitalia, and perineum on the same side, and disturbances of sensation in perineum and external genitalia on the opposite side. This is explained by the sensory fibers of the pudendal plexus decussating lower down than do the sensory fibers for the limbs.[1]

FRACTURES AND DISLOCATIONS OF THE SPINE

As already stated, fractures of the vertebræ are rather rare injuries. They occur in the statistics of Stimson in only 0.5 per cent of all his factures. Among 270 cases collected by Gurlt there were 178 fractures in the cervical region, 184 in the dorsal region, and 82 only in the lumbar region. The fractures in the cervical region were much the most fatal. Among the 136 cases of fracture and dislocation of the vertebræ collected by Wagner and Stolper 34, or about 25 per cent, were in the cervical region, and of these the vertebræ fractured were the third, ten times; the fifth, five times; the sixth, eleven times; and the seventh, once.

Men during the active period of life are the most frequent victims. These injuries are rare in childhood and in old age and less frequent in women. The bodies of the vertebræ are the parts most often fractured. In the upper cervical region fractures of the body are less frequent, and fracture of the body occurs with increasing frequency from the middle cervical region downward to the lumbar region. In the last nearly all fractures are of the bodies. In the cervical and upper dorsal regions more than one vertebra is commonly fractured, the frequency of fracture of more than one vertebra decreasing from above downward.

Fractures of the bodies of the vertebræ may be incomplete; the body may be broken into several fragments, or not infrequently, crushed. Fractures of the spinous processes occur most often in the cervical region and in the dorsal region; a small proportion only in the lumbar region. The fracture may occur

[1] Bailey, *loc. cit.*, pp. 196, 197.

alone or be associated with fracture of the body of a vertebra above it, or below it. Fractures of the transverse or articular processes are rare, except in combination with fractures of other portions of the bones. The intervertebral discs, the other ligaments, and the muscles and tendons may also be torn in fractures of the vertebræ.

Fractures in the Cervical Region.—The most frequent cause of fractures in the cervical region is sudden forcible flexion of the neck. Such may be caused by falls upon the head or by direct violence to the neck itself. The body of the vertebra is most often broken and the fractures are frequently associated with dislocation. Dislocations may also occur without fracture. In fractures of the cervical region by direct violence the signs of contusion and laceration of the soft parts are frequently present. Mobility and crepitation are more apt to be present than in fractures lower down. In these cases movements of the patient are very apt to be followed by increased injury to the cord. Malposition of the head and neck are often noticeable, as already stated; the head may be bent forward or twisted to one side. Cerebral concussion is often marked in these cases, and the patients are often unconscious for some time after the accident. A group of symptoms peculiar to injuries of the cervical cord are those due to paralysis of the cervical sympathetic. They are contraction of the pupil of the eye, sinking in of the eyeball, narrowing of the palpebral fissure, flushing of the face, and loss of the cilio-spinal reflex—that is to say, dilatation of the pupil from irritating the skin of the neck over the upper third of the sterno-mastoid muscle or just below that point. When the lesion involves both sides of the cord the sympathetic symptoms are very marked. Severe lesions in this region are almost uniformly fatal at an early period. In some cases, as in certain fractures of the atlas and axis, death is instantaneous from compression of the medulla, and yet such is not always the case. For example, Gurlt (quoted by Stimson)[1] collected eleven cases in which the nature of the injury was confirmed by autopsy. Of these, death was instantaneous in only two, and in two more within an hour. In the others the patients lived for a number of days. In one the patient received an injury of the neck and walked home without symptoms of paralysis. Death took place on the eleventh day, probably as the result of some movement which caused an additional injury to the cord. In the cases collected by Gurlt of fractures of the atlas and axis, in those who lived long enough for the symptoms to be studied, there was complete paralysis of all the parts below the fracture in some, partial paralysis in others. Pain was complained of in the back of the neck in several. In nearly all the neck was rigid. In none was there a recognizable deformity, except in one where the head fell forward upon the chest. It is, therefore, impossible in these cases to differentiate between fracture and dislocation, since the same train of symptoms is common to both. As already stated, severe lesions above the fourth cervical segment are always immediately fatal. In fractures of the fifth cervical seg-

[1] L. A. Stimson, *loc. cit.*, p. 149.

ment—i. e., the fourth cervical vertebra—and below where the lesion is severe the distribution of the paralysis and the attitudes of the patients are quite characteristic and permit a fairly accurate localization. They are thus epitomized by Bailey.[1]

Fifth Cervical Segment (*Fourth Cervical Vertebra*).—Paralysis of all extremities, except perhaps scapula muscles. Patient can shrug shoulders. Breathing diaphragmatic. Anesthesia from second intercostal space, including all of arms.

Sixth Cervical Segment (*Fifth Cervical Vertebra*).—The biceps, the supinator longus and brevis, the brachialis anticus, and the deltoid escape complete paralysis. The patient can flex forearm and raise arm, and lies with forearm and hands slightly flexed, with the upper arms slightly abducted and rotated from the trunk. Anesthesia the same as in fifth-segment injury, except that the radial side of the arm is not involved.

Seventh Cervical Segment (*Fifth Cervical Vertebra*).—The triceps is not extensively paralyzed, neither are pronators of arm. The patient, therefore, can extend and rotate forearm. The arms lie folded on the chest. Distribution of anesthesia not to be absolutely differentiated from that of C. vi.

Fig. 15.—Anesthesia in a Case of Fracture of the Cervical Vertebræ, with Injury to the Eighth Cervical Segment. (Bailey.)

Fig. 16.—Fracture Dislocation of the Spine in the Lower Dorsal Region; no Cord Symptoms. (New York Hospital.)

Eighth Cervical Segment (*Sixth and Seventh Cervical Vertebræ*).—Paralysis limited to below elbow; parts of fingers only; possibly, also, of fingers and wrist. Anesthesia in ulnar distribution. (See Fig. 15.)

First Dorsal Segment (*Seventh Cervical Vertebra*).—Paralysis both motor and

[1] Bailey, *loc. cit.*, pp. 201, 202.

sensory, that of ulnar-nerve distribution. These distributions represent the severe and fatal types of injury. In less severe cases some of these symptoms may be wanting on one or both sides. The motor paralysis is usually more marked on one side than on the other. One arm may retain considerable power. Paralysis of both arms, without involvement of the legs, is characteristic rather of primary hematomyelia than of fracture. The type of spinal hemiplegia is sometimes observed. In one case quoted by Bailey, localized motor paralysis was wanting, though anesthesia was present. In general, the fewer and less marked the symptoms the better the prognosis. If the knee-jerks are preserved and the patient retains control over his bladder, the prognosis is much more favorable.

Dorsal Lesions.—In this region are included the portions of the spinal cord from the second through the twelfth dorsal segment. This portion of the cord is protected by the first ten dorsal vertebræ. In this region the fractures almost always involve the bodies of the vertebræ, and the external deformity, or kyphos, is usually marked. Fractures of this region result from severe degrees of direct violence. The cord is never injured without injury to the bones. The lesions to the cord are apt to be severe. Frequently the cord is compressed or crushed by the displaced vertebræ. Fractures in this region are less frequent than in the cervical region; in Gurlt's cases 71 out of 270. The prognosis is rather better than in injuries of the cervical region, though not much. The paralysis has no special characters which have not already been mentioned, but, as already stated, the injuries are apt to be fatal.

FIG. 17.—FRACTURE DISLOCATION OF THE SPINE IN THE LOWER DORSAL REGION; NO CORD SYMPTOMS. View from behind of the same case as shown in Fig. 16. (New York Hospital collection.)

Lumbosacral and Cauda Equina Lesions.—Injuries to this region interfere with the movements and sensibilities of the legs and with the functions of the bladder, rectum, and of the sexual organs. The lumbosacral region of the cord extends from the

upper border of the eleventh dorsal vertebra to the lower border of the first lumbar. It is divided into five lumbar and five sacral segments, each segment giving off a pair of nerve roots, which go to form the cauda equina, and the last sacral giving off also the coccygeal nerve. The three lower sacral segments are called the *conus medullaris*. The important functions presided over by the lumbosacral cord are crowded into small compass, the entire length of all ten segments not exceeding three and a half or four inches. The cauda equina is much longer. The roots of the lumbar and sacral segments which make it up extend directly downward from their origins, the lower the root the more internal being its situation. (See Fig. 18.) They pierce the dura opposite the same intervertebral and sacral foramina by which they emerge from the spinal cord. From the first lumbar nerve behind the eleventh dorsal vertebra to the space between the sacral and coccyx, where the coccygeal nerve emerges, is a distance of from eight to ten inches. No single nerve root is so long as this, but the sacral roots have a course in the spinal canal of from five to six inches. The cauda is covered throughout by the dura. The roots which compose it have distinct motor and sensory functions, as the union of them to form mixed nerves takes place outside of the dura where also, on the sensory root, before its union with the motor, posterior ganglion is situated. The cauda completely envelops the cord, so that no injury to the lumbosacral region can occur without an accompanying injury to the cauda, but the cauda, below the termination of the cord, may be injured alone. In such cases, from focal signs alone, it may be impossible to determine whether the injury is to cord or to roots.

The diagnosis of injuries in this region are thus quite difficult. The lesions are frequent and usually severe. More than half of all fractures and dislocations of the spine take place below the tenth dorsal vertebra. The vertebræ most often involved are the last two dorsal and the first lumbar. Injury of these three give mixed cord and cauda lesions. Lower down, pure cauda lesions occur.

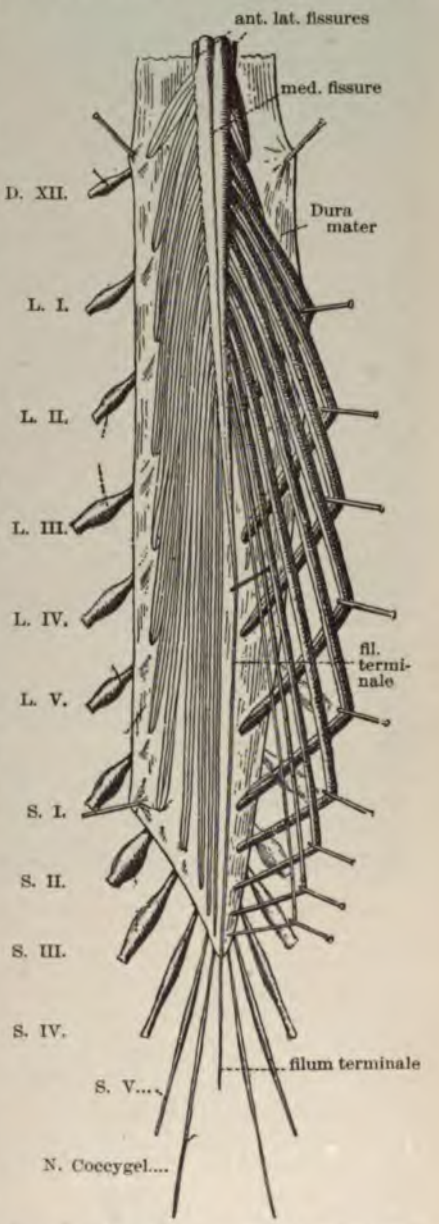


FIG. 18.—DIAGRAM OF THE LUMBOSACRAL REGION OF THE SPINAL CORD AND OF THE CAUDA EQUINA, AFTER OPENING THE DURA. One half natural size. (Bailey, after Van Gehucten.)

These injuries result from extreme violence. Men during the active period of life are usually the victims. The bodies of the vertebræ are the parts usually

FIG. 19.—OLD FRACTURE OF THE TENTH AND ELEVENTH DORSAL VERTEBRÆ, MARKED ANTERIOR DISPLACEMENT, COMPLETE CRUSH OF THE CORD. (New York Hospital Museum.)

fractured, and dislocations are frequently observed together with fracture. The deformity of the back is marked. The chief object in diagnosis is to determine

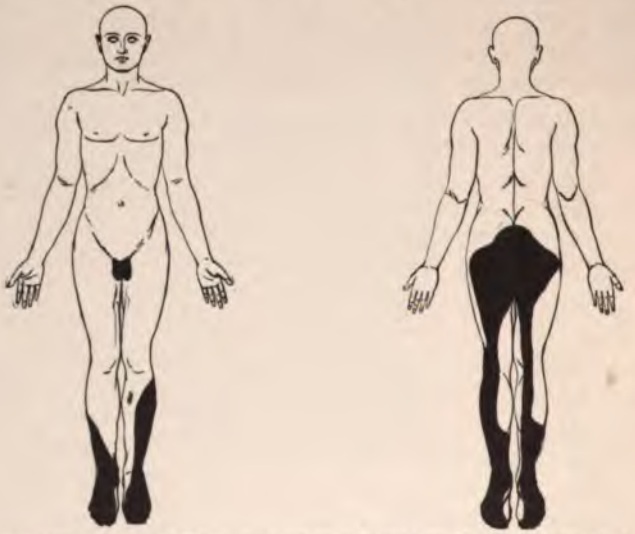


FIG. 20.—ANESTHESIA IN A CASE OF FRACTURE OF THE TWELFTH DORSAL VERTEBRA. (After Bailey.)

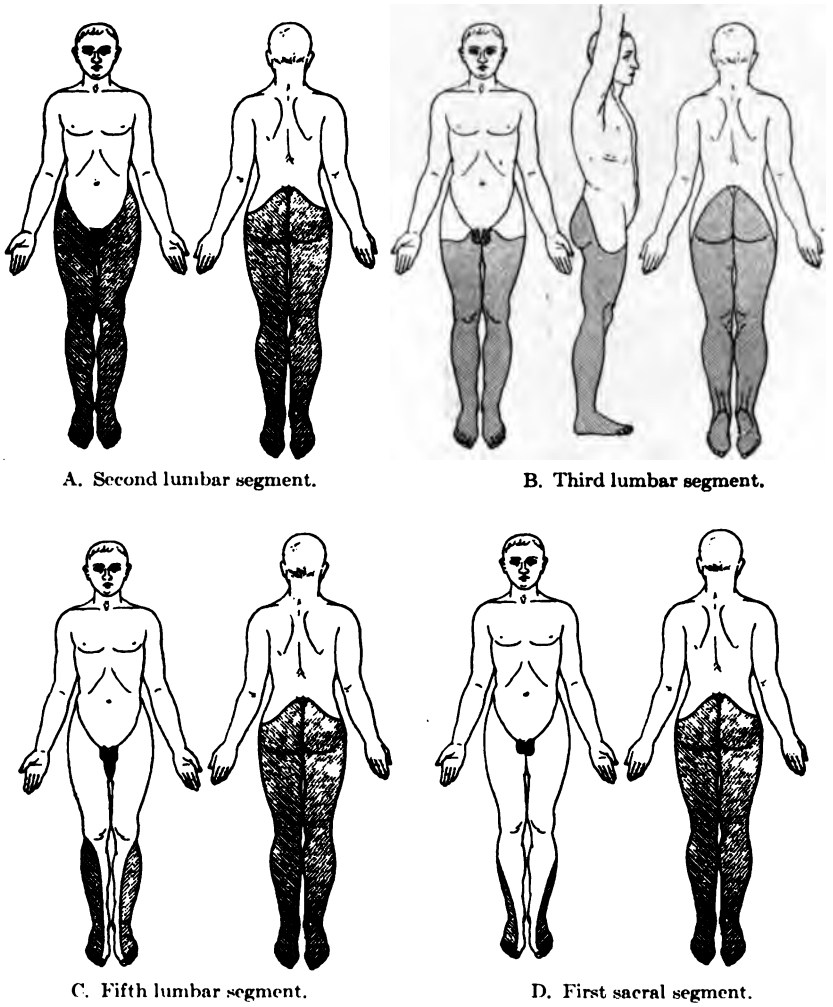
whether the cauda or the cord are solely or chiefly affected. In cauda injuries alone the prognosis is much better. The following diagnostic points are of value: If the compression is at or below the second lumbar vertebra, the lesion is of the cauda only. Cord lesions are usually painless. Cauda lesions, though painless at first, are apt to be followed by sharp pains down the legs when function begins to return. In cauda lesions the anesthesia is more widespread, more irregular, and less profound than in lesions of the cord. Involuntary twitchings of the muscles

FIG. 21.—OLD FRACTURE OF THE FIRST LUMBAR VERTEBRA WITH CRUSHING OF THE BODY. (New York Hospital Museum.)

is characteristic of cord lesions, and atrophy is more pronounced in these than in those of the cauda. The course of the case may throw some light on diagnosis. As in other injuries of the cord, the early symptoms do not necessarily represent the extent of the permanent damage. For example, an injury to the conus, in addition to the paralysis of the bladder and rectum and the anesthesia characteristic of conus lesions, may present a general weakness of the legs, diminution of knee-jerk, and scattered areas of anesthesia in the legs. In the course of a few days these latter symptoms, indicating injury to the cauda, may greatly improve or pass away entirely, leaving the conus symptoms alone as permanencies.

Fractures of the sacrum or of the pelvis may cause symptoms suggestive of intervertebral lesions. Thus, a fracture of the sacrum may compress the roots going to form the sacral plexus, or compression or traction of the sciatic may cause

paralysis of that nerve. The latter diagnosis presents no difficulties. In the former the surgical examination of the bones, external and by rectum, and the frequently unilateral character of the symptoms, are usually sufficient to prevent confusion. From the charts on motor and sensory localization the symptoms of injury to the lumbar and sacral segments can readily be deduced. In injury to the upper half of the lumbar cord there is complete paraplegia. This may be produced by fracture dislocation of the tenth and eleventh, or eleventh and twelfth dorsal vertebræ, or by fracture of the twelfth dorsal vertebra. (See Fig. 20.) In injury



A. Second lumbar segment. B. Third lumbar segment.

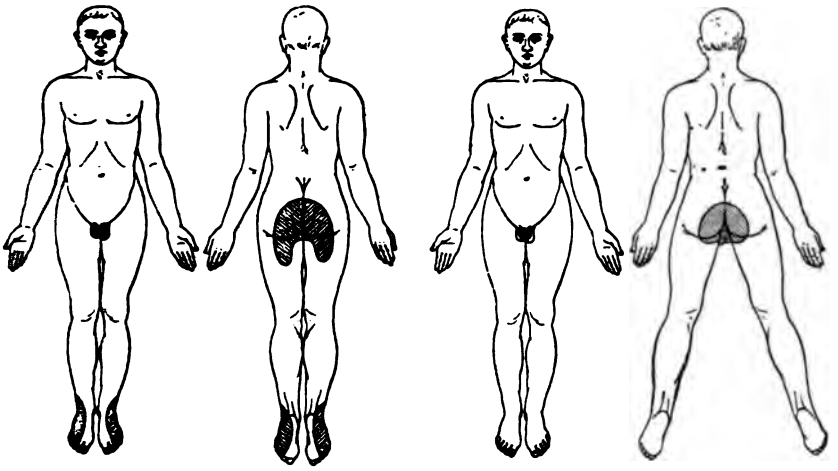
C. Fifth lumbar segment. D. First sacral segment.

FIG. 22.—ANESTHESIA IN LESIONS OF THE LUMBOSACRAL REGION. (Bailey, after Müller.)

to the lower half of the lumbar region of the cord sensibility is preserved on the anterior aspect of the thigh, and the adductors and quadriceps are only partially paralyzed or not paralyzed at all. The knee-jerk is not lost if the lesion is below the second, third, and fourth segments, and if the roots from these segments are

not affected. Rare cases of conus or cauda lesions have been reported, in which, with absent knee-jerk, there was a foot clonus.

Fractures and dislocations of the first and second lumbar vertebræ are the ones usually responsible for sacral lesions. Injury of the two upper sacral segments gives the anesthesia and paralysis indicated on the charts, without loss of knee-jerk,



A. Second sacral segment.

B. Third sacral segment.

C. Fourth sacral segment.

FIG. 23.—ANESTHESIA IN LESIONS OF THE LUMBOSACRAL REGION. (Bailey, after Müller.)

provided the lumbar roots are not affected. (See Figs. 22, 23.) These two segments have been termed the epiconus. Injury of it causes paralysis, especially pronounced in the peronei muscles.

Pure conus lesions are characterized by lack of paralysis of the limbs, by paralysis of the bladder and rectum, a saddle-shaped area of anesthesia over the buttocks, with anesthesia of the penis and scrotum. In all pure sacral lesions the testicular sensation is retained, as the testicle receives its sensory innervation from the lumbar plexus.

The center for erection being in the second sacral segment, and that of ejaculation in the third sacral, if the lesion is below these segments, procreation is possible.[1]

Prognosis in Fractures of the Spine.—As already stated, in about one third of the injuries to the spinal column the cord escapes. In these the prognosis is the same as in any other fracture. The prognosis of severe total transverse lesions of the cord, except in the lowest segments, is absolutely bad. Death occurs from the complications already mentioned sooner or later. It is, however, extremely difficult to differentiate total from partial lesions immediately after the accident. In many cases, though the symptoms may indicate a total lesion at first, considerable improvement may take place as time goes on, showing that some portion of the cord has escaped destruction. In a general way, the fewer and less marked the symptoms the better the prognosis. A very favorable sign is preservation of the control of the bladder. Preservation of sensation indicates a partial lesion, as does also the presence of only partial motor paralysis. Old age, alcoholism, and other general depressing conditions render the prognosis worse here, as in other injuries. The sooner the symptoms begin to improve after the accident the more likely it is that the patient will survive and continue to improve. Bailey states that, as a general rule, if the patient is to make a relatively good recovery, indications of it are apparent within two weeks after the accident. Once improvement has commenced, it may go indefinitely for years. With the same amount of injury, the higher placed the lesion the worse the prognosis. Severe injuries of the cervical region and in the upper dorsal region are usually fatal within a short time. In rare cases, however, severe injuries of the cervical region may survive for a long time. In many cases of injury to the cervical region it is apparent from the first that the destruction of the cord is not extensive. Such patients may recover quite rapidly, though some weakness is apt to be left, notably in the upper extremities. Bailey considers that less improvement follows injuries in the dorsal region than in any other, and that, though these patients may live for a considerable time, they are apt to die sooner or later of infection of the genito-urinary tract from bed-sores, etc.

The statistical records of various observers in regard to the prognosis of fractures of the spine indicate that these injuries are always serious when the spinal cord is involved. Thus, of 44 cases received at the Hudson Street Hospital 25 died; in 8 cases the patients passed from observation and the ultimate outcome was unknown, 9 left the hospital improved, and 2 only were cured (P. R. Bolton, quoted by Bailey). In Gurlt's statistics, of 270 cases there was a mortality of 80 per cent, and in Burrell's 82 cases a mortality of 78 per cent. Among his cases there were 22 per cent who survived. In one half of these the patients were able to resume work. To what extent the mortality is

[1] Bailey, *loc. cit.*, pp. 208–212. The above paragraphs are partly quoted and partly adapted from Bailey.

diminished and the prognosis improved by operation it is difficult to say, since many unsuccessful operations are not reported and at the present time very few serious cases are operated upon at all, the operated cases being now very carefully selected. Among 167 operated cases collected by Chipault only 21.5 per cent recovered or improved. In 56 cases collected by Thorburn the mortality was 67.8 per cent. The improvement observed in some of the operated cases would probably have occurred had the operation been omitted. The only object accomplished by operation, and that in exceptional cases, is the relief of pressure.

Injuries to the cauda equina, while less serious than injuries of the cord, are not infrequently fatal in the end, and though many cases improve, in others a portion of the disability remains permanent. The chances of improvement are increased by operation in these cases. It is rare indeed, however, that injuries of the spinal cord are so completely recovered from that the patient is as well off as he was before the accident.

Dislocations of the Spine.—Many dislocations of the spine are associated with fracture. Indeed, pure dislocations are almost confined to the cervical region. The fourth, fifth, and sixth cervical vertebræ are the ones most often dislocated. As in cases of fracture, dislocations are commonly due to a forced flexion of the neck, occasionally to forcible abduction or rotation, rarely to extension. The force usually acts indirectly, as in falls upon the head or upon the buttocks. Occasionally the violence is direct and acts immediately upon the dislocated vertebræ. Dislocations from muscular action are extremely rare. Spontaneous dislocation of the vertebræ may occur from disease involving destruction of the bodies of the vertebræ and the retaining ligamentous structures.

Varieties of Dislocation.—*Unilateral Dislocation Forward.*—The mechanism of this form of dislocation is that the lower articular process upon one side is raised by lateral flexion and then lifted over the articular process below it by rotation. The intervertebral disc may be partly torn or remain nearly intact. If the violence continues, a rarer form of dislocation may be produced—the so-called *bilateral dislocation in opposite directions*; i. e., one articular process is dislocated forward, the other backward. *Bilateral dislocation forward* is accompanied by rupture of the intervertebral disc in nearly all cases. It occurs from violent flexion of the neck, so that the articular processes of the upper vertebræ are caused to slip over and in front of the processes of the vertebræ below after the restraining ligaments have been torn across. The upper vertebra slips forward and its dislocated articular processes sink into the notch in front of the processes of the lower vertebra. These dislocations are usually followed by marked forward flexion of the head upon the chest. *Distortion, or diastasis,* of the spine occurs, as already stated, for the most part in the lower cervical region at or about the level of the fifth and sixth cervical vertebræ. There is no actual dislocation, or, if such has occurred, the bones slip back into place. The cord is injured by traction in its long axis, and the resulting lesion to the cord is commonly hemorrhage (primary hematomyelia). Dislocations

in the dorsal and lumbar regions not associated with fractures are rare. More than one half of the observed cases have been *dislocations of the twelfth dorsal vertebra.* Among the most important and fatal dislocations is *dislocation of the atlas from the axis.* It is most commonly an incomplete bilateral dislocation forward. Such dislocations can only occur after rupture of the transverse ligaments, fracture of the odontoid process, or after slipping of the odontoid process beneath the transverse ligaments after the check ligaments have been torn. Such dislocations may be produced by falls or blows upon the head. They are occasionally observed from hanging. In most cases the cord is crushed and death is immediate. In a few no cord symptoms have followed, and the patient may live for many years, although marked flexion of the head exists as a deformity and is usually accompanied by some stiffness and pain. In some cases the odontoid process is fractured and is displaced forward along with the dislocated atlas. In these cases the danger of fatal compression of the cord is diminished.

Symptoms and Diagnosis of Dislocations of the Vertebræ.—It is to be borne in mind that nearly all pure dislocations occur in the cervical region. The cord symptoms are the same as those produced by fracture. The symptoms referable to the injury of the bones are local pain and tenderness, pain upon active and passive motion. The spine is usually held rigid. The most certain aid in diagnosis is an X-ray picture or, preferably, stereoscopic X-ray pictures of the injured spine.

Deformity of a more or less characteristic kind may be recognized. In unilateral dislocations forward the neck may be abducted toward either side. In forward dislocation of the atlas upon the axis a prominence may sometimes be felt at the back of the neck, formed by the spinous process of the axis. Palpation in the pharynx permits one to feel the projecting anterior arch of the atlas. Where the dislocation is incomplete and the inferior articular process of the upper vertebræ rests upon and not in front of the one below the neck is bent toward the sound side. Kocher and Wagner believe that in complete unilateral dislocations the flexion is toward the injured side. Some other authorities believe that it is in the opposite direction. The face is usually rotated toward the sound side. In complete dislocations the head, as stated, is rigid. In incomplete dislocations motion is possible, though painful. The spinous processes in complete dislocations are rotated toward the injured side. It is, however, only possible to feel that of the axis and of the two or three lower cervical vertebræ. The transverse process on the injured side is prominent in front, as well as the corresponding half of the body of the vertebra. The transverse processes can be palpated in the lower part of the neck from the front. The bodies of the upper three cervical vertebræ can be palpated in the pharynx. In bilateral dislocations forward the symptoms vary greatly. The head may be bent forward and the spinous processes of the vertebræ below the one dislocated may be prominent at the back of the neck. In other cases the head is bent backward or to one or the other side. The variations in position of the head and neck appear to de-

pend in part upon the position of the dislocated bone, in part upon the direction of the dislocation, partly upon muscular spasm or its absence, and partly upon the presence or absence of associated fracture. The occurrence of bilateral dislocation backward is so rare that accurate observations have not been made. In the cases described the head has been bent backward, there has been interference with swallowing and respiration, the structures upon the front of the neck have been tense, and the face has been directed upward.

WOUNDS OF THE SPINAL CORD

Gunshot Wounds of the Spinal Cord.—The majority of gunshot wounds involving the spine are serious or fatal on account of associated injuries of the abdominal and thoracic viscera. It is only those bullet wounds fired from behind in which the spine and the spinal cord merely are injured. The bullet may have the same effect as a total crush of the cord—i. e., it may destroy completely its continuity. In some cases the bullet may only partly divide the cord, in others the cord is lacerated or compressed, not by the bullet itself, but by bone fragments. If the bullet remains in the spinal canal, it may become the center of a focus of infection, which may remain localized or, in rare cases, lead to a fatal meningitis. In other cases the bullet does not cause suppuration, but produces a gradual and progressive compression of the cord by the formation of adhesions and the production of new connective tissue. The symptoms produced by bullet wounds of the cord resemble those due to other forms of violence. Partial lesions occasionally occur. Bailey points out that in bullet wounds the lesion sometimes may point to an injury higher up than the position of the bullet. Such symptoms are due to an extension upward from the point where the cord was injured, of softening or of hemorrhage.

Stab Wounds of the Cord.—Stab wounds of the cord are most frequent in the cervical region, rare in the dorsal region, and occasional in the lumbar region. The wound of the cord is often unilateral, and the injury may be upon the opposite side of the cord from that at which the knife blade or dagger entered. The symptoms produced are usually of the Brown-Séquard type. The mortality in 46 cases reported by Roeseler (quoted by Bailey) is 71 per cent for the two upper cervical vertebræ, 53 per cent for the four upper cervical vertebræ, and 23 per cent for the three lower cervical vertebræ, or 40 per cent for the entire cervical region. In the dorsal region the mortality is 31 per cent. In the fatal cases the patients die from bed-sores, cystitis, etc., as in other injuries of the cord. In the cases which recover, the first symptoms to improve are the paralysis of the bladder and rectum and later on the paralysis of the limbs. The legs recover more completely than the arms. Perfect recovery, however, is rare.

PRIMARY FOCAL HEMATOMYELIA

Primary focal hematomyelia is a lesion which until the past few years has received but little attention. It has been especially studied in America by Bailey and Bolton. From their investigations it appears that the lesion is much more frequent than has generally been supposed. The most characteristic symptom of the condition is *dissociated anesthesia.* The condition results almost exclusively, if gunshot wounds are excepted, from sudden forced flexion or extension of the neck, and the most common cause of all is diving into shallow water. Bailey believes that the hemorrhage into the horns of the gray matter is caused by overstretching of the cord during forced flexion or extension of the neck.

Symptoms.—The signs of fracture and dislocation of the vertebræ are wanting. There may be edema, ecchymosis, stiffness, and pain in the neck. In the most severe cases, when the hemorrhage extends beyond the gray matter of the cord and causes a complete and destructive transverse lesion, the symptoms

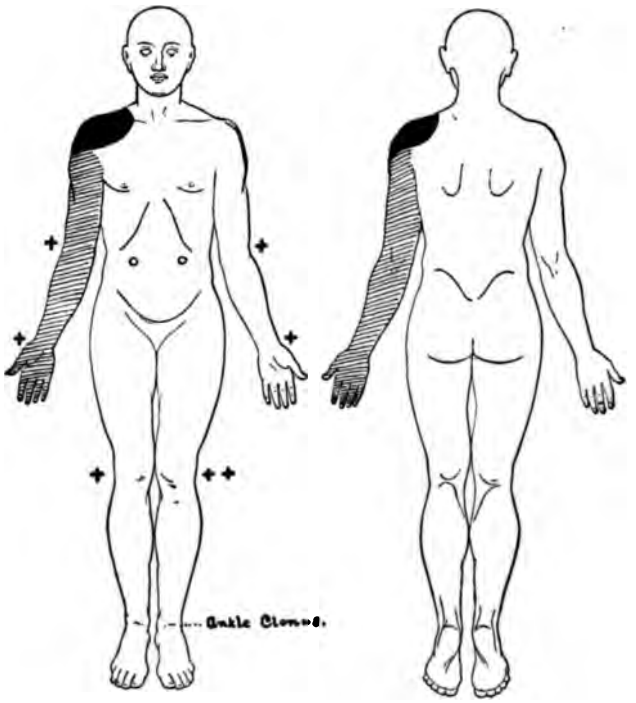


FIG. 24.—DIAGRAMMATIC REPRESENTATION OF THE ANESTHESIA AND THE CONDITION OF THE DEEP REFLEXES IN A CASE OF PRIMARY FOCAL HEMATOMYELIA FROM INJURY. (After Bailey.)

will be those of a complete crush of the cord. When, however, as is more common, the hemorrhage is confined to the gray matter the symptoms have a distinctive character. They consist of an initial motor paralysis, which soon becomes modified, and of anesthesia for temperature or pain, or both, without

impairment of the sense of touch. The motor paralysis usually ensues instantly after the injury. The muscles involved are those of the forearm and hand and sometimes of the upper arm; those below, of the lower extremities. The paralysis of the upper extremities is produced by hemorrhage, which injures or destroys the motor nuclei of the brachial nerves. This paralysis is not completely recovered from. The patients do not completely regain their power in the upper extremities. The paralysis of the legs, on the other hand, is often recovered from completely. It is due, in the opinion of Bailey, to the pressure exerted by the blood-clot within the gray matter upon the pyramidal tracts of the cord or to edema. These tracts carry the fibers extending from the brain to the motor nuclei situated at lower levels. When the hemorrhage ceases and its immediate effects have passed away these fibers regain their function.

The distribution of the paralysis varies with the situation and extent of the hemorrhage. If below the first thoracic segment, the arms escape. If above the second thoracic segment, the paralysis affects the muscles whose nuclei are below the upper limit of the hemorrhage. If the hemorrhage is very small and on one side of the cord only, the paralysis may affect one arm chiefly or solely; if larger, but still confined to one side, there is spinal hemiplegia.[1]

Bailey considers that the condition of diplegia brachialis traumatica probably belongs to primary hematomyelia. In this condition the symptoms are as follows:

After an injury to the cervical region there develops at once a flaccid paralysis of both arms, the legs escaping, or being only slightly involved. There is severe pain in the neck, which radiates down the arms. These symptoms have been commonly explained by assuming an extramedullary hemorrhage, or a tearing or crushing of the nerve roots.[2]

In many cases of hematomyelia there is at first paralysis of both arms and legs, flaccid in character, sometimes with complete paraplegia. The knee-jerks are absent or diminished. If the lesion is very small the knee-jerks may be exaggerated at once. The paralysis of the lower extremities soon undergoes a change to the spastic type. The knee-jerks, if diminished or lost, return and become exaggerated, to which is added ankle clonus. With the spasticity, power returns to the legs. Some patients are able to walk in a few weeks after having been paraplegic. Improvement in the legs comes on sooner than in the arms and is more complete. In most cases there is permanent paralysis with atrophy in some of the muscles of the upper extremity.

The improvement in sensation varies in different cases. In all but the most extensive cases where all forms of sensibility may be lost, these being rare, sensibility to touch is preserved, while there is loss of temperature sense, or pain sense, or both together. The distribution of these disturbances is in general the

[1] Bailey, *loc. cit.*, p. 225. [2] *Ibid.*

same as that after the total anesthesia of transverse lesions. The Brown-Séquard type is often seen—viz., "a motor paralysis of one arm and leg, with loss of pain sense and temperature sense in the arm and leg of the opposite side." [1] The loss of pain sense is, as a rule, less marked than that of temperature sense, and during recovery the former is the first to improve or disappear. Bailey states that in his experience the loss of temperature sense has been generally, for the first few weeks after the accident, complete.

In some cases there is no pain; in others there is pain, both spontaneous and on motion, referred to the site of the lesion. "The so-called irritative root symptoms—i. e., the sharp lancinating pains down the arms or legs—are not frequent in pure central traumatic hematomyelia; nor are numbness, tingling, or other forms of paresthesiæ frequent." [2] The patients frequently state that they feel everything, being ignorant of the fact that they cannot feel or distinguish between heat and cold. Since the lesion is in the cervical region, some paralysis of the sympathetic nerve is constant. There is contraction of the pupil. "If the amount of blood on the two sides is equal, the degree of myosis will also be the same on both sides." [3] Usually it is more marked on one side than on the other. Other symptoms sometimes occur: disturbances of the bladder and rectum, bed-sores, priapism, edema, blueness of the extremities, tympanites, chills and fever. They are rarely all present together and are characterized by their brief duration. The power of the rectum returns first, later on the control of the bladder.

Diagnosis.—The nature of the accident, the absence of evident bone lesions, the extent and character of the paralysis of voluntary motion, and the paralysis of the bladder and rectum may be the same as in any spinal-cord injury. In this group of cases, however, the most important diagnostic guide is the characteristic disturbance of sensation as related. The only serious difficulties in diagnosis will arise in the very slight cases where the amount of hemorrhage may not be sufficient to produce sensory symptoms, and in the very extensive cases where the hemorrhage is so large as to produce death. In these latter it is impossible to differentiate a hemorrhage from a total transverse and destructive lesion of the cord from external pressure.

Prognosis.—In the mild and moderately severe cases the prognosis as regards life is excellent. The prognosis as regards useful function in the lower extremities is also good. As stated, some of the muscles of the arms and hands may, and often do, remain permanently weakened. At the outset it is often difficult to determine the extent of actual destruction in the cord, since symptoms may for a time point to rather extensive injuries. Usually in a few days the symptoms begin to improve rapidly. Of favorable omen are: preservation of the control of the bladder and rectum, absence of bed-sores, and a rapid return of function in some or many of the voluntary muscles.

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[1] Bailey, *loc. cit.*, p. 226. [2] *Ibid.*, p. 228. [3] *Ibid.*

CONCUSSION OF THE SPINAL CORD

The term concussion of the spine has been used in times past to indicate very diverse trains of symptoms following injuries of the most varied character to the back. The designation "railroad spine" was formerly much used as a name for generalized nervous disturbances following such violence as was experienced by persons in railroad accidents, where the individual was severely shaken up physically and very much frightened. During recent years and after an enormous amount of careful study and observation the symptom-complex, formerly known as "spinal concussion," has come to be more and more restricted, and at the present time the majority of neurologists have arrived at the belief that spinal concussion is, properly speaking, a misnomer. From what has preceded in this chapter, it is very evident that serious and even fatal lesions of the spinal cord may be produced by concussion of the spinal column, and that without any evident fracture or dislocation of the vertebræ. The lesions thus produced may be hemorrhages into and around the cord, or laceration and even total destruction of that organ. By the term "spinal concussion" as ordinarily used, no such conditions as these are implied, but rather a train of symptoms of a psychical character, characterized largely by neurasthenic and hysterical symptoms. In other words, the phenomena observed in the cases ordinarily designated as spinal concussion are rather those of mental shock than of any actual pathological lesion of the spinal cord. In times past spinal concussion has played a very important part in suits for personal damages brought against railway companies and the like, and enormous sums of money have been paid to such plaintiffs, so that a definitive conclusion on the part of the medical profession as to whether there is such a condition as concussion of the spinal cord producing symptoms apart from those due to laceration and hemorrhage is very important. Unfortunately, at the present time, the profession as a whole is not entirely agreed upon this point. While the great majority of observers believe that concussion of the spinal cord does not exist as a pathological entity, a few do still so regard it. It is certain that concussion of the spinal cord is in no wise parallel with concussion of the brain. The spinal cord is far better protected than is the brain against external violence. Moreover, the symptoms of concussion of the brain appear instantly at the time of the injury and are of short duration. The symptoms designated as due to concussion of the spine, on the other hand, if the cord be really injured, though they may appear at once, are of long duration and slow to subside. When no pathological lesion of the cord can be demonstrated, the condition known as spinal concussion is characterized, as already stated, by phenomena, which are more properly mental and belong in the psychical group of conditions known as "traumatic neuroses." These neuroses may be divided into three groups about to be described. They include traumatic neurasthenia, traumatic hysteria, and unclassified and mixed forms. In some of these cases there may be the symptoms immediately after the accident of contusion or sprain of the back, and

occasionally of an actual injury to the cord. In some cases a period of unconsciousness follows the accident, and this is followed by extreme nervousness, a constant feeling of dread, by insomnia and the frequent occurrence of horrible dreams and nightmares. Frequently, pain and stiffness in the back and limbs are complained of and the other symptoms of the traumatic neuroses to be presently described. When the actual injuries, sprains, contusions, wounds, or other, have been recovered from, the case ceases to be one which greatly interests the surgeon and passes into the domain of the neurologist; and yet it is highly important that the surgeon should be able to recognize these conditions.

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CHAPTER II

THE TRAUMATIC NEUROSES

It is well known that latent nervous diseases, epilepsy, locomotor ataxia, general paralysis, may be rendered worse by fright or mental shock, but in speaking here of the traumatic neuroses, we shall confine ourselves to a brief description of the nervous symptoms which may follow sudden mental shock, frequently combined with extreme terror and horror, and not uncommonly combined with more or less serious physical injury. The two neuroses which commonly follow such accidents are "traumatic neurasthenia" and "traumatic hysteria," together with combinations of these two conditions. This subject has acquired an enormous and constantly increasing importance, especially from a medico-legal point of view. These nervous disorders follow especially the accidents, constantly increasing in number, which depend upon the complicated mechanical devices now a part of civilized life, notably in the great centers of population. By far the largest proportion of the cases of traumatic neuroses result from railway accidents. With the rapid development of railway traffic, the number of these cases is constantly on the increase. A certain proportion of cases follow trolley-car accidents; others are due to electric shocks from contact with live wires carrying electricity at high potential. Numerous cases arise as the result of fires, explosions, earthquakes, and similar catastrophes, in which many persons are killed and injured. Certain facts are worthy of remembrance. It is not the railway employee, who perhaps loses a limb, or is severely crushed in a railway accident, nor the electric lineman who is badly burned by contact with an electric conductor, who develop traumatic neuroses; nor in general are these neuroses developed in the cases where really serious injuries are received. Those who are asleep when a railway accident occurs and those who are drunk are less likely to suffer from subsequent derangements of the nervous system than are those who, being fully conscious at the time of the accident, undergo the indescribable terror and fear of impending death experienced by those who are passengers in a railway wreck or other similar catastrophe. In the majority of cases the individuals who subsequently suffer are those not seriously hurt. They may be severely shaken up or bruised, or merely badly frightened. In some cases the nervous symptoms begin at once after the accident; in others, not for days, or even weeks. The influence of litigation is very marked in bringing on and increasing the severity of the symptoms of the traumatic neuroses, and it is also noteworthy that after such litigation is

finished the patients often improve very rapidly. (For the data contained in the sections on Traumatic Neurasthenia and Traumatic Hysteria, the author is largely indebted to Bailey, *loc. cit.*, p. 398 *et seq.*)

TRAUMATIC NEURASTHENIA

Symptoms.—The symptoms of traumatic neurasthenia, while very varied, may be stated briefly as follows: The patient is an individual, more often a man than a woman, who has previously enjoyed good health. He is in an accident, more often a railway accident than any other. At the time he is more frightened than hurt. He may be injured more or less seriously, in which case the surgical condition will give its ordinary symptoms. In some cases he is rendered unconscious from fright; in others, he is only dizzy, dazed, or confused. He may be more or less exposed to the weather, and may witness the death of other persons, or see the bodies of those who have been killed and mangled—all of which add to his fright and mental depression. During the succeeding days he may feel physically fairly well, but is nervous, has a constant sense of dread, and sleeps badly at night. The neurasthenic symptoms may come on at once, or be delayed for several days or even for weeks. He will usually complain within a few days of a pain in the back. The proper neurasthenic symptoms may be arranged, for purposes of description, into several groups.

Mental Symptoms.—The mental changes constitute the most characteristic phenomena of the disease. The patient becomes fretful and irritable. The trifling annoyances of life, which formerly he disregarded, become sources of pain and irritation. He dislikes loud noises. His eyes cannot bear a strong light. He becomes intensely selfish and introspective. The cares of his business and the welfare of his family, which were formerly objects of intense interest, become secondary considerations while he dwells constantly upon his own miserable condition and upon his real or fancied symptoms of physical disorder. He is emotional and fearful, and suffers from palpitation of the heart. He studies his own symptoms with the greatest care and is constantly engaged in reviewing and studying them. He desires to talk only to those who listen with apparent interest to the story of his ailments. He is mentally depressed and discouraged. Suicidal tendencies are not present in simple cases of neurasthenia. He suffers greatly from mental fatigue, is unable to concentrate his mind upon anything, although really his mental powers are but slightly, if at all, impaired. Fear is the predominant symptom in these cases. He is afraid to go out in the streets for fear he will be run over; he dare not ride in a railway train for fear of another accident; he finds it hard to make up his mind to do anything; he sleeps badly and has frequent bad dreams and nightmares; he seeks solitude. The general appearance of the individual may remain unchanged, or in other cases he may become pale and look out of health. His facial expression is usually sad and mournful.

Motor Symptoms.—There is no paralysis in traumatic neurasthenia, but the general tone of the nervous system is often somewhat impaired. Extreme muscular fatigue follows slight exertion. The patient is disinclined to walk, and a walk, for even a short distance, may bring on extreme fatigue. Tremor is a frequent symptom. It resembles the tremor of alcoholism, is a fine and rapid tremor, greatly increased by emotional disturbances and by fatigue. It occurs most frequently in the tongue, the hands, and face.

Sensory Symptoms.—The commonest and most pronounced sensory symptom is pain in the back. The pain occurs in two forms. First, a dull aching pain, sometimes referred to the entire back, sometimes localized in the back of the neck or the lower portion of the spine—i. e., the small of the back, in the upper lumbar region. In addition to the pain, certain portions of the spine may be tender upon pressure, though these tender areas may vary in situation from day to day. The patient is made worse by fatigue.

Pain of another character also occurs and is believed to be due to actual strain of the muscles of the back. It has received the name of "traumatic lumbago." It is usually the first symptom to appear after the accident, and is the basis upon which the other nervous disturbances are built. It is believed to be due to strain or laceration of some of the muscular or ligamentous structures which surround, protect, and support the spinal cord. This pain usually comes on within a few days after the accident, sometimes at once. It is not usually a continuous or spontaneous pain, and if the patient keeps perfectly quiet he may be fairly comfortable. When he moves or is subjected to a sudden jar the pain becomes worse. The pain is of a severe character, so that the patient may cry out from the slightest movement of the spine. It may be felt along the whole course of the spinal column, but more commonly is localized in some particular region. It may be referred to the neck, the dorsal region, or the lower end of the spine (coccygodynia). Palpation or even the slightest touch over the painful area may greatly increase the patient's suffering. Pressure over the spines of the vertebræ in the painful area greatly increases the discomfort.

A sign first described by Mannkopff and known as the Mannkopff test is sometimes of value to eliminate simulation. If the finger be placed upon the patient's pulse before pressure is made over the tender vertebræ, it will sometimes happen that spinal pressure causes a marked acceleration of the pulse-rate. It is not always present in these cases, but if present it indicates either that the patient really does suffer an increase of pain, or that at any rate he fears such increase. The muscles of the back are usually in a state of spasm and may feel as hard as boards.

The attitude of the patient is somewhat characteristic. In standing the back may be seen to be held perfectly stiff and rigid. The patient usually bends a little forward, and if one side is more painful than the other, a little to one side. If the patient is asked to pick up an object from the floor, he does not bend his back to do so but gets down upon one knee. All his movements are made slowly and carefully to avoid any jarring of the spine. I had such a

patient under my care a few months ago in the New York Hospital. He was an employee of one of the city departments and had been hurt between the shoulders by an empty barrel falling upon him out of a cart. His back was somewhat bruised and strained, but not seriously. He was entirely incapacitated for work, could only walk with two canes; he lifted his feet but slightly from the ground and shuffled slowly and carefully along. He could not get out of bed or dress himself unassisted. During the time I had him under observation his symptoms did not improve.

In some of the cases difficulty in evacuating the bladder and rectum may be complained of. There is no true paralysis, the difficulty being merely the increased amount of pain caused by the muscular efforts necessary in the acts of urination and defecation respectively.

Headache is one of the common symptoms of traumatic neurasthenia. It may be felt in the occipital region, or over the eyes, or the patient may have the feeling as though a tight band were fastened about his head. There may also be true neuralgic pains in special nerve trunks. If the patient has received bruises, wounds, or sprains of any part of the body, pain and tenderness continue in these regions long after the injury is healed.

In addition to local pain, these patients frequently suffer from a general sense of fatigue which amounts to pain. They have a constant feeling of being tired. In addition there may be a general hyperesthesia of the skin and of the muscles, or such hyperesthesia may be localized in different areas. This symptom is rendered worse by fatigue.

Anesthesia is not a symptom of traumatic neurasthenia. When found it points to organic disease or to hysteria. These patients, however, frequently complain of indefinite numbness, of tingling, without sharply marked localization. They may suffer from shivering attacks without feeling cold.

Special Senses.—*Eye Symptoms.*—The most constant symptom referable to the eyes is dimness of vision; that is to say, these patients find that the eyes become fatigued very soon when used and that objects soon become dim. They have the sensation of a veil before the eyes, and after reading for a few minutes the letters upon the page become indistinct. There is also felt a hypersensitiveness of the eyes to a bright light. The patient prefers to sit in a darkened room. There is no contraction of the visual field, properly so-called, except that since the eyes become so readily fatigued, tests applied to determine the field of vision will show that if the examination is prolonged the visual fields of both eyes will exhibit a constantly increasing contraction. So that, whereas at the beginning of the examination the visual field may be normal, or nearly so; if the examination be continued, the field of vision will be observed to grow smaller and smaller. This is known as the "shifting type" of contraction of the visual field (Förster). There is no reversal of the normal color fields, such as is commonly observed in hysteria. The acuteness of central vision remains normal.

Hearing.—Oversensitiveness of hearing is frequently a marked symptom in traumatic neurasthenia, so that slight noises become a source of pain and annoy-

ance to the patient. Abnormal sensations are also complained of, such as buzzing and ringing in the ears, dizziness, and other symptoms which give the patient a good deal of anxiety. The patient may complain of a feeling of dizziness, a sense of things spinning around, and the fear of falling, and yet these persons may be able to stand erect with the eyes closed, and although the swaying may be greater than in healthy persons, it does not correspond in extent to the gravity of the subjective symptoms.

Reflexes.—Neither the deep nor superficial reflexes are lost in simple traumatic neurasthenia. When the reflexes are absent or diminished, it should excite suspicion of organic trouble.[1] The knee-jerks are usually exaggerated, so that a slight tap upon the patellar tendon produces a quick and marked extension of the knee. Ankle clonus and the Babinski reflex do not occur (Bailey). The tendon reflexes of the upper extremity, often absent in health, are usually well marked in neurasthenia. If there be pain or hyperesthesia upon one side of the body, the superficial reflexes may be increased on that side. All the reflexes become quickly tired.

Disturbances of Circulation.—Palpitation of the heart is commonly present in neurasthenics and may be very marked indeed, suggesting in severe cases an attack of angina pectoris, though the arterial degeneration and character of the attacks in the latter condition are absent. In neurasthenia the pulse is commonly accelerated, and during the attacks of palpitation the pulse-rate may be 130 or 150 per minute. Such attacks may be associated with pain over the heart. Other disturbances of circulation are sensations of heat and cold in the extremities, blueness and coldness of the extremities, with increase of perspiration and attacks of alternate flushing and paleness of the face.

Disturbances of Digestion.—In nearly all cases of neurasthenia the digestion is disturbed. The appetite is usually normal, but the patients suffer from gastric dyspepsia, a coated tongue, and constipation. The breath often has a foul odor. Eructations of gas after eating are common. Vomiting is rarely a symptom. Eating of a hearty meal is often followed by an attack of palpitation of the heart. In a few cases there is nervous diarrhea.

In neurasthenia the sexual functions may be interfered with. In women menstruation is often abnormal, and in men psychical impotence is a frequent symptom. In some cases there is urina spastica; and phosphaturia with neutral or alkaline urine is not uncommon. The turbid appearance of the urine in some of these cases is a cause of grave anxiety on the part of the patient.

Diagnosis.—A certain amount of nervous dread together with loss of sleep and disturbances of digestion following a severe fright or mental and physical shock is common, even with normal individuals, and does not constitute a disease. If, however, the symptoms of neurasthenia coming on after an accident persist and grow worse, the diagnosis of traumatic neurasthenia may be made after eliminating organic diseases, such as diseases of the heart, nephritis, and

[1] Bailey, *loc. cit.*, p. 420.

serious organic diseases of the nervous system. A disease which may be confounded in its early stages with traumatic neurasthenia is general paresis. In the latter the early mental symptoms may be neurasthenic, but the organic changes are evinced by the Argyll-Robertson pupil, etc. In one third of the cases of paresis the knee-jerks are lost; in others they remain normal, or may be exaggerated in the early stages of the disease. The tremor of the tongue in paresis is also characteristic. In melancholia the pronounced symptoms are persistent insomnia, loss of flesh, restlessness, extreme mental depression, usually delusions, and sometimes suicidal tendencies. In cases of hypochrondriasis there is a distinct hereditary taint. Neurasthenia may often be combined with traumatic hysteria, but in the former the stigmata of hysteria are wanting—namely, paralysis, contracture, anesthesia, muscular spasms, and the typical contraction of the visual fields.

Prognosis.—The prognosis of traumatic neurasthenia is by no means uniformly good. Recovery is usually delayed, and may be rendered incomplete by the mental strain and excitement always involved in those cases which come to litigation. In many instances after a suit is decided in favor of the plaintiff with substantial damages, the neurasthenia improves and often gets well, but this is due to the fact that during the time pending the decision of a suit the plaintiff is kept in a state of continual anxiety and mental unrest by numerous medical examinations, by absence of proper treatment, and by the law's delay, as well as by the irritation and trying conditions present during the trial of the case. Many of the litigants get the discredit of simulation or exaggeration which they do not deserve, since the strain and excitement of the trial really makes them much worse. The prognosis is far better if no suit is brought and where the patient can be properly treated after the accident by rest, seclusion, and the care of an intelligent physician. In a few cases traumatic neurasthenia remains unimproved for an indefinite period. In others, improvement occurs, so that the patient is able to return to his work, and yet he never really feels as well as he did before the accident. In still others, and these are probably the majority, cure eventually takes place. It has been said by one who has observed many cases, that the prognosis as to cure is unfavorable if the symptoms persist for three years (Knapp). Patients also who are treated in clinics frequently do not do well, the circumstances being such that they are constantly thrown in contact with other similar sufferers and are encouraged to dwell upon their own symptoms.

TRAUMATIC HYSTERIA

Hysteria is a disease affecting the entire nervous system, the pathology of which is obscure, but which gives rise to a train of symptoms perfectly real to the patient, and at the present time as clearly marked as those of any other disease. The condition, when it occurs spontaneously or aside from traumatic causes, is much more frequent in women than in men; but as the result of trauma, the relative frequency is reversed and the majority of cases of traumatic

hysteria are observed in males. Hysteria has this definite character—namely, that persons who suffer from it are notably suggestible to a far greater extent than is the case with normal men and women. It was believed by Charcot that hysteria depended upon a form of degeneracy affecting the nervous system and usually due to some hereditary taint. Charcot divided hysteria into two types, hysteria major and hysteria minor. The latter type is the one commonly observed in America, the former being rare. In America it is more often observed in persons of foreign birth than among the native-born, and is more common among the Hebrew race than among others. The causes of traumatic hysteria may be injuries of the most varied character, whether slight or severe. Among the chief diagnostic characters of the condition may be mentioned that in many instances the injury is slight, is often combined with psychic shock, and that the symptoms characteristic of the hysterical condition do not arise at once, *but only after a period during which the patient meditates on his condition, and largely by autosuggestion induces the hysterical symptoms.* The paralyses, anesthesia, and contractures occur chiefly in the part injured. For example, if the individual is injured in one arm, it will be the arm which is paralyzed, or anesthetic, or contracted. It is not to be forgotten, however, that combined with the hysterical symptoms there may be real injury of the nerves, the muscles, or other structures. As already stated, while women develop hysteria of the nontraumatic variety much more often than men, when the disease develops as the result of injury, it is more frequent in men than in women. Any age may be affected, from childhood to advanced life, but the majority of cases occur during the period when individuals are normally most active—i. e., the working period of life. Hysteria has this character distinguishing it from neurasthenia. In the latter the symptoms are often caused by and nearly always made worse by litigation; in hysteria, on the other hand, the symptoms appear quite irrespective of the question of damages and usually soon after the accident.

Causes.—An hereditary predisposition plays a rather important part in cases of nontraumatic hysteria. In traumatic cases a neurotic heredity is less frequent. Among other causes may be mentioned depressed states of health in great variety—notably any condition of enfeeblement of the nervous system from the effects of chronic disease or chronic poisoning (especially alcohol). Among the conditions predisposing to hysteria may be mentioned syphilis, diabetes, nephritis, and chronic poisoning by mercury and lead. Mercury appears to predispose strongly to hysterical phenomena, and it is believed that the so-called mercurial tremors observed in those who are suffering from chronic mercurial poisoning have an hysterical origin.

The exciting causes of traumatic hysteria which concern us here are psychic shock and injury. The element of fright in the production of hysteria, after any given injury, is very marked. Thus, if an individual finds himself in a position of peril and believes that he is going to be hurt, he is much more likely to develop hysteria as the result of the subsequent injury, however slight, than though the accident happens to him unawares. It is for this reason that per-

sons who have been in railway accidents and the like and who are as a consequence at once the victims of extreme terror and of physical violence are more apt to develop hysteria than others.

Symptoms.—The symptoms of hysteria may be divided into those which are permanent—i. e., are observed throughout the course of the disease commonly known as hysterical stigmata—and paroxysmal or accidental symptoms. Under the permanent symptoms, or stigmata, are included the mental state, anesthesia, and the affections of the special senses (Bailey). Under the paroxysmal symptoms are included the paralyses, the contractures, the convulsions. Inasmuch as hysteria affects the entire organism, the function of any organ in the body may be disturbed. Bailey states that anesthesia and contracture of the visual fields are particularly constant, and generally exist together. Paralysis is less common, and when it occurs is nearly always combined with anesthesia. Tremor is also a common symptom. The greater the variety of symptoms shown in the individual case the greater the probability that the patient was hysterical before the accident. Among children the symptoms are usually few in number, paralysis being the most common. Among adults the symptoms may be few or many, and occasionally but a single symptom will be present. In these last the diagnosis is difficult, and it is often impossible to eliminate simulation. In most cases, however, numerous symptoms are present, and their characters are generally such that a positive diagnosis may be made.

Mental Symptoms.—The most marked mental symptom observed in hysteria is the mental state which causes the patient to mimic various forms of organic disease. Such mimicry is carried out in a far more perfect manner than is possible by any voluntary effort, and it is to be borne in mind that many of the symptoms are unconsciously produced. This fact is well illustrated by the perfect manner in which uneducated persons who do not know what hysteria means are able to closely mimic diseases of whose existence they are ignorant. It should be distinctly understood that, although the symptoms are unreal, their exhibition is involuntary and often unconsciously performed by the patient. The unreality of the symptoms can often be proved by hypnotic suggestion. In the hypnotic state the defects of vision, the paralyses, the contractures, and anesthesia may disappear.

Loss of memory, one of the most notable symptoms of the hysteric mental state, differs from the loss of memory due to organic disease, since it is confined to certain events or classes of events, and may be limited to forgetfulness of certain limited periods of time. Thus, hysterical patients may forget the periods preceding or following a certain accident, though they may remember other events very well. Recent events may be forgotten, while events long past are remembered perfectly. These patients are commonly regarded as liars.

Impairment of will power is a constant accompaniment of hysteria. The patient lacks the power to undertake the simplest acts, whether physical or mental. He may be aroused and made to do certain things, but soon becomes tired, inattentive, and confused. Exaggerations of the psychical activities are usually

absent in traumatic cases. Convulsions, catalepsy, sleep-walking are rare phenomena in these cases, though they are occasionally observed, and yet, as Bailey states, we constantly meet clinical contradictions in the same patient. Thus, anesthesia and hyperesthesia may exist side by side. Skin areas may be anesthetic to some stimuli and hyperesthetic to others. The muscles may show a loss of irritability, as in paralysis; or a heightened irritability, continuous, as in

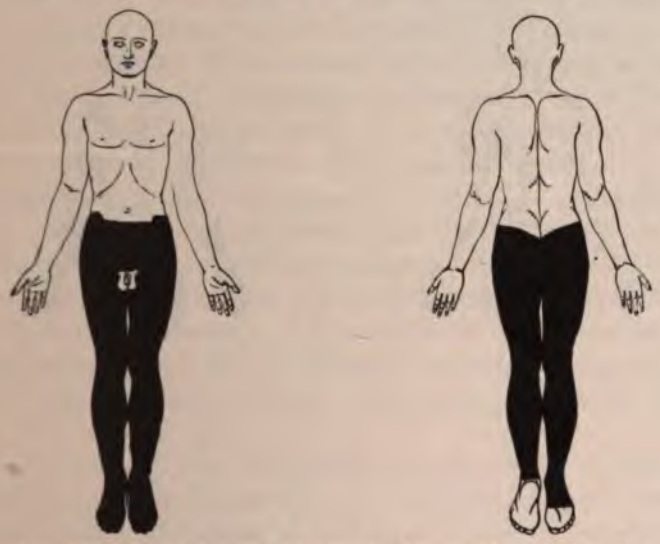

FIG. 25.—ANESTHESIA IN A CASE OF HYSTERICAL PARAPLEGIA. (Bailey, after Souques.)

contracture; or intermittent or rhythmic, as in morbid movements.[1] There is always a profound disturbance in the emotional sphere and the personality undergoes a variety of changes. The individual the victim of traumatic hysteria is moody, introspective, and depressed; his mental state approaches that of melancholia more nearly than that of mania. The patient is inattentive, inactive, and indifferent and shows a loss of interest in his surroundings.

SENSORY SYMPTOMS.—*Anesthesia.*—Hysterical anesthesia is a symptom of which the patient is frequently unconscious and which is rarely a subject of complaint. Often he does not know that it exists until its presence is pointed out to him by the physician. This anesthesia is unreal in that sensations are really perceived, but apparently they do not enter the field of consciousness. Thus, a patient with hysterical anesthesia of the hand does not bruise, cut, or burn himself unconsciously, thus showing a marked difference from anesthesiæ produced by division of nerves or by organic disease of the central nervous system. *This anesthesia constitutes by far the commonest symptom of hysteria.* It is usually total, all forms of sensibility being lost or impaired throughout the anesthesia area. Dissociation of sensation is, however, observed occasionally (Bailey). In these cases loss of pain-sense, with preservation of the sense of

[1] Bailey, *loc. cit.*, p. 458.

touch and temperature, is the commonest form, though other combinations are observed. The loss of sensibility may be complete or only partial; so that slight stimuli are not perceived, while more active stimulation meets with a response. The borders of the anesthetic areas are usually sharply marked and the distribution is commonly unilateral. In ordinary types of hysteria the anesthesia commonly includes half the body (hemianesthesia), including the mucous mem-

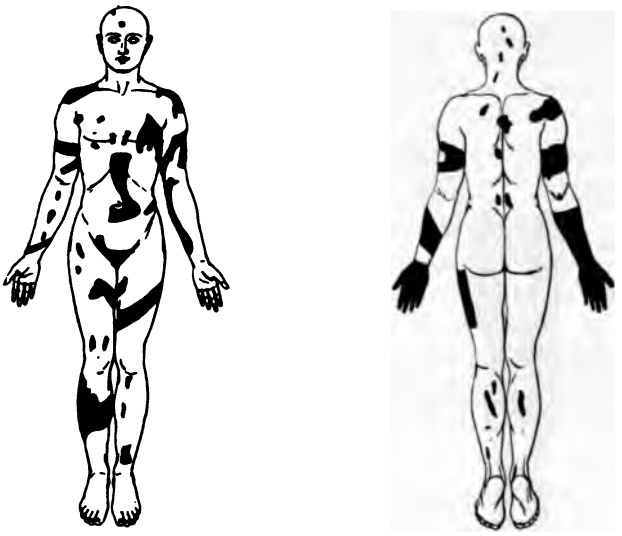

FIG. 26.—DISSEMINATED ANESTHESIA (HYSTERICAL.) (Bailey, after Pitres.)

branes of the mouth and throat and the conjunctiva. In traumatic cases, however, the anesthetic areas usually correspond with the parts paralyzed. If there is hemiplegia, there will be hemianesthesia. If the patient is paraplegic, there will be loss of sensation in both lower extremities, extending to the waist. In these cases, however, the genital organs and perineum usually escape.[1] In paralysis of single limbs or parts of limbs the anesthesia may be limited to the paralyzed extremity, there may be irregular areas of anesthesia scattered over the paralyzed part, or the anesthetic area may be in the shape of a glove or a stocking. In still other cases there will be anesthetic areas scattered irregularly over the entire surface of the body. The distribution of hysterical anesthesia differs from that due to organic disease or injury of the nerves. It never follows the areas of distribution of sensory nerve trunks, nor does it correspond with the anesthesia observed after destructive lesions or diseases of the different spinal segments. It may be temporary, intermittent, or permanent. It is sometimes absent during sleep and during hypnosis. Its situation may change from time to time, or may be made to change by hypnotic suggestion, or by the action of magnets. The appearance of the skin and mucous membranes in hysterical anesthesia is normal. (See Fig. 11.)

[1] Bailey, *loc. cit.*, p. 461.

Hyperesthesia and Pain.—Hysterical patients complain of pain in various places, either spontaneous or excited by external stimuli. The slightest touch upon certain areas of skin, the slightest movement of an hysterical joint or a trifling jar, may cause the patient to scream with pain. In some cases light touches cause exquisite agony, while firm pressure is well borne. If the patient knows that the part is to be touched, the pain is rendered more severe. If his attention is distracted, the painful part may sometimes be touched or pressed upon without exciting expressions of discomfort. The areas of hyperesthesia vary in size and situation. Hyperesthesia of the entire body is rare. Of half the body it is more common. Hyperesthetic areas may also be found scattered over the anesthetic zones. In males the testes and in females the ovaries are common situations of hyperesthesia. The areas surrounding the injured part are often hyperesthetic—that is to say, if the arm has been injured, hyperesthesia will be complained of in the hand; if the back, hyperesthetic zones will be found over the spine. A very common symptom complained of is the sensation of a nail being driven into the head. Neuralgic pains are sometimes complained of along the course of different nerves, notably the fifth nerve and the sciatic. In some cases pressure upon the hyperesthetic zones may bring on a paroxysmal attack, or in others pressure during a paroxysm may cause the attack to cease.[1]

The pain of hysteria does not produce the deterioration of general health caused by real pain from an organic lesion. Hysterical patients frequently sleep well; nor are profound changes of nutrition produced—emaciation, anemia, etc.—such as we see in those who suffer real pain for long periods.

Special Senses.—*The Eyes.*—Next to anesthesia, impairment of the eyesight is the most constant symptom of hysteria. There is often anesthesia of the conjunctiva, and when the eyelids are touched these patients do not wink. The pupils, the ocular muscles, the optic nerve, and the refracting media of the eye are, unless some previous organic disease has existed, found normal. In spite of the really normal condition of the eyes, impairment of vision may be present, or even complete blindness of one eye. Blindness of both eyes is very rarely observed. Upon examining the eyes with the perimeter, it is usually found that the visual fields are diminished in size. In the majority of cases the contraction of the visual fields is slight; in others it may be very marked indeed. When slight, the contraction usually follows the boundaries of the normal field, but when more marked it may be concentric, so that only a small central area remains sensitive to light. The contraction usually affects both eyes, but it is often more marked on one side than on the other, and the side of greater contraction will correspond with the side of paralysis and anesthesia. This contraction of the visual fields varies much from time to time, and may be increased by sources of excitement such as augment other hysterical symptoms. Bailey states that:

[1] Bailey, *loc. cit.*, p. 464.

Associated with this limitation of vision for white are characteristic abnormities in the color fields. With contraction of the visual field for white, the perception of the most internal colors may be lost, or when the contraction for white is only moderate in degree, there may be a reversal of the normal color fields; thus, red may be seen in a larger field than blue.[1]

Strangely enough, hysterical impairment of vision is often present without the patient's knowledge. In addition to disturbances of vision, there may be spasm of the eyelid and motor disturbances in the muscles which move the eyeball. Double vision may occur, and even double vision with one eye—that is to say, with one eye closed the patient may see two lights, whereas there is but one.

Hearing.—Partial loss of hearing is quite common on the same side as the paralysis or anesthesia. Ringing in the ears and other subjective sensations are sometimes present. Complete deafness is very unusual, and when it occurs is commonly associated with some organic disease of the ear. Deaf-mutism is a rare condition in hysteria, but has been observed. It generally occurs suddenly, and may follow an hysterical convulsion immediately after the accident. Speech and hearing are, after a time, in most cases, completely restored. Loss of the senses of taste and smell are occasionally observed. It is commonly associated with anesthesia of the mucous membrane of the mouth and nose.

Motor Symptoms.—*Hysterical Paralysis.*—Hysterical paralysis is an occasional, not a constant, symptom of hysteria. The traumatic variety follows injuries, usually of a slight character, though occasionally severe, especially in those cases where the injury has been accompanied by sudden terror or nervous shock. It possesses this peculiarity—namely, that it rarely comes on at once, but only after a certain lapse of time, during which the patient has been dwelling upon the accident and its results. This time intervening between the accident and the onset of pronounced hysterical symptoms was characterized by Charcot as the "period of meditation," during which the patient dwells upon his injury, upon his pain and discomfort, until suddenly or gradually the paralysis, anesthesia, etc., develop. The character of the paralysis varies. It may amount to no more than a general muscular weakness; usually, however, special muscles or groups of muscles are involved—in some cases, all the muscles of a limb; in others, only certain muscles. Further, it may happen that while some of the motor functions of groups of muscles cannot be performed, others can be performed perfectly well. From this it may happen that certain peculiar forms of paralysis are produced. Among these is that type in which the patient is unable to walk (astasia-abasia). The patient may lie in bed and move all the muscles concerned in walking with ease and plenty of power, but when he stands up and tries to walk he at once falls to the ground. He may even be able to stand upon his toes, to jump, and even to dance, but walking is impossible.[2] It is always the case that the paralysis is worse when the patient's attention is attracted to it or during the medical examination, and indeed in all cases the paralysis varies

[1] Bailey, *loc. cit.*, p. 466.

[2] *Ibid.*, p. 472.

greatly from time to time. So long as the patient remains markedly hysterical the paralysis continues and tends to grow worse. The commonest distributions of the paralysis are hemiplegia, monoplegia, and paraplegia.

Hemiplegia occurs more often upon the left side than upon the right. The face is not involved, thus showing a marked distinction from true organic hemiplegia. There may, however, be slight drooping of the corner of the mouth and sometimes spasm of the muscles of the face. The leg is more completely paralyzed than the arm. The knee-jerks are usually not much increased and foot clonus is absent, except in some cases of hysterical contracture in which the foot is in the position of equinus. The gait of *organic hemiplegia* is characteristic. The patient bends his body toward the sound side, in order to lift the paralyzed leg off the ground, and swings it forward and outward through the arc of a circle, producing the well-known "mowing" gait. In *hysterical hemiplegia*, on the other hand, the paralyzed leg is dragged along the ground as though it were an inert mass. In organic hemiplegia the patient tries his best to use the paralyzed leg, and nearly always makes some use of it. In organic hemiplegia there is little or no loss of tactile sensibility in the paralyzed part. Hysterical hemiplegia is accompanied by anesthesia of the paralyzed half of the body and, in addition, there is usually impairment of vision and other special sense organs.

Monoplegia (paralysis of one limb) is a frequent form in traumatic hysteria. The arm is more often involved than the leg and the left side than the right. About one half the cases are of the traumatic variety. In some cases the entire limb is paralyzed; in others, only the muscles of the forearm or hand. The impairment of function varies. In some cases it amounts only to weakness of the muscles; in others to complete paralysis. In some cases it is associated with anesthesia of half the body; in others only the paralyzed limb or a part of it is anesthetic. Atrophy of the muscles is absent or slight in hysterical paralyses and the electrical reactions usually remain normal, although slight impairment of electrical excitability is occasionally, though rarely, observed. The upper borders of the anesthesia, where a limb is affected, are often marked by a circular line about the extremity—that is to say, they do not correspond with any nerve distribution.

Though the arm is most frequently the seat of hysterical monoplegia, paralysis of the leg and of other parts—the face, for example—has been observed. The anesthesia of hysterical paraplegia extends usually from the waist downward. The genitals, however, are not involved, except in very rare cases, in which the external genitals may be hyperesthetic or anesthetic. Paralysis of all four extremities is occasionally observed. In cases of hysterical paralysis and anesthesia, ataxic movements may occur. The gait of the patient may resemble that of well-advanced locomotor ataxia. Some of these patients cannot stand upright with the eyes closed, and many of them sway from side to side more than is the case with normal individuals. In other cases ataxic movements of the upper extremities may be observed. In these cases the diagnosis depends

upon the elimination of the signs of organic disease and the discovery of some of the characteristic signs of hysteria.

Contractures.—In traumatic hysteria, spasmodic contraction of groups of muscles, usually of the extremities, is not unusual. It may be associated with paralysis or there may be no loss of power, except such as is implied by the spasmodic contraction of the muscles. Such contractures may come on suddenly; more commonly, however, they are slow in development. There is a difference between the contractures of hysteria and those of organic disease. In the latter the contractures develop slowly, and it may be weeks or months before they are pronounced, and even then the contraction may be partly overcome by passive movements. Such is not the case in hysteria. In these the muscles surrounding a joint may be in a state of tonic contraction, so that no moderate amount of force can overcome it. The joint or limb is held absolutely rigid.[1] In organic disease the reflexes are exaggerated (knee-jerk and ankle clonus). In hysteria the reflexes are rarely much increased. The history also is a valuable diagnostic aid. Hysterical contractures occur after injuries too slight to profoundly affect the nervous mechanism—i. e., to produce any organic change. The contractures may be transitory, of long duration, or even permanent. They do not relax during sleep, but disappear under a general anesthetic, and may often be diminished by hypnotic suggestion. According to Bailey, the form taken by the contractures differs from the organic type. For example, when the arm or the leg, or both, are involved, the arm is drawn across the chest, the forearm is partly flexed, the wrist is flexed, and the fingers are firmly flexed into the palm. The hand may assume various positions, according to the preponderance of contracture in one or other group of muscles. When the interossei are contracted the hand is held in the position for holding a pen. The lower extremities are usually held immobile and straight. The ankles and toes are often in a position of equino-varus. In other cases the legs are held in the same position of flexion as is seen in organic disease of the spinal cord. The diagnosis must be made by examining the reflexes, by search after other signs of hysteria, and by the condition of the muscles. Other groups of muscles are sometimes involved, those of the tongue producing difficulties of speech. Spasm of the muscles of the neck may produce torticollis. Spinal curvature may be produced by spasm of the muscles of the back, and spasm of the abdominal muscles may produce the so-called "phantom tumors."

Tremor.—Trembling is an almost constant symptom of traumatic hysteria. It is most often observed as a fine, rapid tremor of the hands and fingers, or it may mimic the tremor of paralysis agitans, or be still more coarse, like the tremor of multiple sclerosis. It is made more pronounced by excitement and fatigue, and usually disappears during sleep.[2] It is usually confined to certain groups of muscles, though it may be generally distributed. Other peculiar movements are sometimes observed in hysteria, such as fibrillary twitchings of

[1] Bailey, *loc. cit.*, p. 480.

[2] *Ibid.*, p. 483.

various muscles or forcible clonic contractions of groups of muscles. Such are often observed when the patient attempts to make some coördinated movement. To the normal movement of the limbs there is often added a series of clonic spasms and of movements in excess of those required for the attempted action.

Hysterical Joints.—Hysterical affections of the joints are often observed after slight injuries. They may come on at once, but more often not until after the patient has had time to meditate upon his condition. "The knee-joint is most often involved; after that, in order of frequency, the hip, the wrist, the shoulder, and the ankle." [1] The most marked character of hysterical joints is pain, greatly increased by motion. A careful examination, however, will usually disclose that the pain and sensitiveness are situated in the skin rather than in the joint structures themselves. Moreover, the pain and hyperesthesia are in many cases not confined to the vicinity of the joint, but are complained of in the entire limb. The position in which the joint is held may or may not be that of organic disease. The surest and simplest way of eliminating organic disease in these cases is to put the patient under a general anesthetic—unfortunately, not always possible. When the patient is under ether the contracted muscles relax, the deformity disappears, and the joint becomes freely movable—conditions which do not obtain in organic disease.

I recollect a case of this kind seen while I was interne in Bellevue Hospital, at a time when traumatic hysteria was not so well understood as at present (1886). The patient was a young girl of sixteen who had suffered a trifling injury to the left hip as the result of a fall from a horse car. Some weeks later she was brought to the hospital suffering from what was believed to be at that time an acute inflammation of the left hip-joint. She lay in bed with the left knee- and hip-joints flexed and entirely rigid. The slightest attempts to move her limb were followed by screams of pain. There was exquisite tenderness over the hip-joint, and apparently swelling of the upper portion of the thigh, which was confirmed by measurements. The unusual feature in the case was that the patient ran an irregular temperature which varied between normal and 105° or 106° F. The temperatures were taken with great care so that there was no possibility of tampering with the thermometer. The members of the attending staff then on duty were for a time puzzled as to the true condition, and though redness and edema were absent the girl was put under ether with the idea of making an incision and draining the hip-joint. Under the anesthetic all evidences of disease disappeared. The true nature of the condition was then recognized, and before coming out of ether the limb was placed in splints, so that the position of flexion could no longer be assumed. Some improvement followed, but in the end the splints were removed and the skin over the hip-joint was repeatedly cauterized. Under this treatment the patient rapidly improved and left the hospital soon after, not cured, but in a condition such that she was able to walk.

The occurrence of fever as a symptom of hysteria is denied by many observers. It certainly was present in the above-described case. The diagnosis of

[1] Bailey, *loc. cit.*, p. 484.

such joints, then, depends upon the absence of the signs of inflammation, usually of the well-known positions assumed in diseases of the different joints, in the disappearance of the contractures under anesthesia, and upon the presence of geometrical areas of anesthesia in the vicinity of the affected joint. There is also a serious possibility—namely, that if a joint be held immobile for a long time, actual fibrous ankylosis may occur, and this condition, unless relieved by breaking up the adhesions from time to time under ether, may become permanent.

Reflexes.—The reflexes are rarely exaggerated to a pathological degree in hysteria, though they may be somewhat overactive. Foot clonus is rare, though, as stated, it may be present in hemiplegia and paraplegia, and, as already stated, in these cases the feet will be held rigidly in the position of marked equinus. The clonus, if present, lacks the force, the rhythm, and the persistence of organic clonus. In regard to this, Bailey states that clonus of this character occurs, according to some authors, in twenty per cent of all cases. In rare cases of hysterical paraplegia, however, a form of clonus is observed identical with the organic variety and only to be differentiated from it by other symptoms. For such a differentiation the Babinski reflex is most serviceable, though it should not be forgotten that slight organic clonus may exist without the Babinski reflex. The tendon reflexes may be diminished in hysteria, though they are never lost. They are often diminished when paralysis as well as anesthesia is present.

Sphincters.—Loss or impairment of the sphincteric control of the bladder and rectum is one of the rarest accidents in hysteria. There may be retention of urine, and there is often increased frequency of urination. This may be due merely to a nervous irritability of the neck of the bladder (urina spastica), or it may be due to the nervous polyuria frequently observed in neurotic individuals, notably when in a condition of excitement. Anesthesia of the mucous membrane of the bladder and rectum scarcely occurs as the result of hysteria.

Hysterical Attacks.—Severe forms of hysterical attacks are less common in America than on the Continent of Europe. Their general appearance is familiar to everyone. The only condition from which they must be differentiated is epilepsy, though rarely the two conditions, of course, may be combined. There are certain marked differences between an epileptic attack and an hysterical fit. In epilepsy the convulsion is of short duration, an aura does not always precede the attack, and the convulsions frequently occur at night. The duration of an hysterical attack may be half an hour, or an hour, or more. The attacks rarely occur at night; there is always an aura. In epilepsy, biting of the tongue and the involuntary passage of urine are the rule; in hysteria these phenomena do not occur. During the attack the pupillary reflex to light is lost in epilepsy, present in hysteria. After an epileptic attack the knee-jerk is lost; not so in hysteria. The character of the convulsive movements in hysteria is exaggerated, and opisthotonos is common. After a true epileptic attack the patient passes into a condition of so-called postepileptic stupor which may last

for several hours. The hysterical attack is usually recovered from suddenly and the mind is at once perfectly clear.[1] One of the forms of hysterical attack sometimes seen in the hospitals in New York is the so-called hysterical coma. The patients are usually men who are picked up on the street unconscious and brought to the hospital by the ambulance. They appear to be entirely unconscious and without motion. The action of the heart and respiration remain normal. After a variable time, which may be many hours, these individuals awaken quite well and go home. The occurrence of severe and convulsive attacks may occur at regular intervals and often at the same hour each day. In some cases several attacks occur daily and often at stated intervals. Following these attacks the constant symptoms of the disease are frequently made worse.

A great variety of special and general disturbances other than those already mentioned may form a part of the hysterical picture in the given case. A few of them may be mentioned. Hysterical aphasia is not very rare. These patients are able to make sounds, but they cannot articulate words; unless they are also deaf they are able to read understandingly and to write. Aphonia may also be produced by weakness, or spasm of the muscle of the larynx. These patients are unable to make any vocal sound whatever. Hysterical asthma is not infrequent. These patients breathe very rapidly, are greatly frightened, and complain of want of air. Cyanosis is absent. In other cases there is an expiratory spasm. The patients have an intermittent or persistent cough, or have hiccough, or make strange noises.[2] The digestion may be disturbed in various ways. Constipation is very common. The attacks of palpitation and the alarming sensations connected with the heart have already been mentioned. Localized cyanosis and edema are not uncommon. Fever, though rare, is occasionally observed. Certain peculiar skin eruptions have been described as the result of hysteria, though in this country they are very uncommon. The following case was seen by me through the kindness of Dr. Pearce Bailey some years ago, with the idea of eliminating the existence of an X-ray burn.

A young woman injured her wrist. The surgeon, undecided as to whether the fracture existed or not, used the X-ray for diagnosis. A few days afterwards the arm gradually lost its strength, and ten days later there appeared a vesicular eruption running up the entire anterior surface of the arm and out upon the breast. My examination showed a typical hysterical monoplegia of the arm, with profound anesthesia running out to the breast. The eruption, in no way resembling an X-ray burn, and coinciding with the anesthesia, was regarded as purely hysterical in character.[3]

Hysterical Vertigo.—Patients with hysterical hemiplegia frequently tend to sway and stagger, while standing or walking, toward the paralyzed side. Some of these patients complain of sensations of giddiness and vertigo; in others the sensations, though not complained of, are readily assented to upon suggestion. In some instances the gait closely resembles that of disease of the cerebellum.

[1] Bailey, *loc. cit.*, p. 488. [2] *Ibid.*, p. 491. [3] *Ibid.*

Hysteria in Its Medico-legal Relations.—In traumatic neurasthenia litigation may induce the symptoms, and in all cases makes them worse. Traumatic hysteria, on the other hand, occurs quite irrespective of any question of litigation or of damages. There is, however, no class of damage suits in which justice is less likely to be obtained than in traumatic hysteria. On the part of the plaintiff it is, unfortunately, not difficult to procure expert evidence to the effect that the paralysis, the anesthesia, the contractures, and other symptoms are the direct results of the injury received at the time of the accident, and that they are, moreover, either of an organic nature or that, if their functional character be admitted, they are nevertheless most serious and likely to be permanent. When an hysterical patient appears in court he consciously or unconsciously exaggerates all his symptoms, so that the nervous breakdown, the paralysis, etc., exhibited by the patient himself to the jury may appear to them to be even worse than has been indicated by the testimony during the trial. It is hard for them to realize that a limb paralyzed and contracted to-day may to-morrow be used with perfect freedom. In court, moreover, the hysterical patient is very apt to exhibit violent emotional disturbances, perhaps even to have an hysterical convulsion. The effect upon the minds of the jury is usually that the patient must have sustained a very grievous injury and that in all probability its local effects, so evidently serious when exhibited to those unfamiliar with the extraordinary mimetic powers of the disease, are permanent. The apparent suffering in these cases is usually pitiable. The plaintiff appears to be a nervous wreck, and thus the damages allowed him are usually out of all proportion to the extent of his real injuries.

Prognosis.—That hysteria may be fatal, uncomplicated by any organic disease, is open to doubt; nevertheless, a few cases have been reported in which hysterical patients have died apparently as the result of hysteria merely. Bailey considers that these cases are open to doubt, and says that in no instance, so far as he is aware, has a careful microscopic examination been made of the central nervous system in order to exclude pathological changes. In America cases of traumatic hysteria are often the basis of suits for damages, and as long as the case is in litigation the circumstances are most favorable for a continuation and aggravation of the disease. After the suit has been decided the patients generally recover more or less rapidly. In a large proportion of these cases there is no previous history of hysterical phenomena, nor any evident hereditary predisposition. These individuals usually return to a normal mental state. In children, hysteria usually runs a short course, lasting only a few weeks. In old age hysteria is infrequent, though when it develops it is apt to be persistent and hard to cure. During the middle portion of life cases of traumatic hysteria, unless they have been previously hysterical, or have a strong hereditary predisposition, or, unless the condition is complicated by depressed states of general health, by chronic intoxications, as of alcohol, or by serious organic disease, tend to get well under proper surroundings.

UNCLASSIFIED FORMS OF TRAUMATIC NEUROSES

In addition to the cases of traumatic neurasthenia and of traumatic hysteria, there exists another and much smaller group of cases of mental and general nervous disturbance following injuries, of a far more serious character than either of those just described. In these cases the question has never been definitely answered as to whether organic changes occur in the central nervous system as the result of the accident or not. They are, in other words, best described as borderland cases in which the symptoms in part resemble those of neurasthenia or of hysteria and in part resemble also the symptoms of organic disease. The condition follows accidents of a much more serious character than in the two groups just described. The element of terror or psychic shock may be present or absent. The injuries are such as are produced by machinery accidents when the body of the victim is more or less seriously mangled. It may follow very serious electrical burns, such as are sometimes suffered by electric linemen who come in contact with live wires and are not immediately extricated. The victims are not killed, but may be horribly burned, so that entire limbs, or portions of limbs, or other parts, are so injured that extensive loss of substance results. The symptoms sometimes follow railway accidents in which the body is more or less crushed or mangled. I have seen one case following a dynamite explosion in which the individual was cut and torn and lost the sight of both eyes. Falls upon the head from a great height and other similar serious injuries may be followed by the symptoms of this condition.

Symptoms.—In these cases the physical injuries, the wounds, fractures, burns or other, produce, after the accident, their own definite surgical signs and are finally recovered from in due course of time, but the patient, instead of being able to resume his occupation, is by no means in a condition to return to work. He becomes mentally depressed, apathetic, loses interest in his business and cares not for the welfare of his family. He sits, sad and gloomy, apparently not dwelling upon his condition, but indifferent to all things, thinking of nothing. If aroused he is rendered fretful and annoyed. He desires not to be disturbed. The condition, in other words, closely resembles in many respects the milder forms of melancholia. The physical condition suffers considerably. The patient becomes pale, anemic, and often loses much flesh. In some cases the mental state approaches that of dementia. The patient is apathetic and forgetful. He is inattentive and unable to concentrate his mind upon anything. His speech may be interfered with from inability to remember names and words. The details of the accident cannot be recalled nor the time preceding or immediately following it, though he may distinctly remember events long past.

Motor Symptoms.—Among these tremor is always marked. This is a tremor which may not be observed while the muscles are at rest. It is greatly increased by movement, or by the effort to perform some physical act requiring coördination, and is also marked during excitement and fatigue. This tremor

interferes considerably with the performance of the simplest task. The patient may be unable to write legibly, or to button his clothing. In other cases the tremor is very coarse and resembles the incoördinated movements seen in multiple sclerosis. The tremor is observed chiefly in the hands and arms, though sometimes the head will also shake.[1] It may be so decided that the patient has difficulty in performing the most ordinary acts of everyday life. He may scarcely be able to feed himself properly and when he attempts to drink a glass of water, much of the liquid is spilled. In the more severe cases the tremor extends to the lower extremities so that the patient has difficulty in walking. He walks slowly and with hesitation. The foot may be dragged a little, but there is no evidence of true paralysis. In some cases there is fibrillary twitching of the muscles, notably of the shoulders and face. By the tremor of the tongue and other speech muscles, the voice becomes thick and the speech indistinct; sometimes the voice has a jerky character. Paralysis is not a symptom of this form of neurosis, and when it is observed it is either a sign of hysteria or an indication of organic disease (Bailey). These cases present no symptoms which lead to the diagnosis of a focal organic injury to the nervous system, and, on the other hand, they differ considerably from the symptoms of the purely functional neuroses. Though no muscles are paralyzed, all the muscles are weakened and the patient readily becomes fatigued and even exhausted from slight muscular efforts. The electrical reactions of the muscles remain in most cases normal (Bailey).

The Reflexes.—The knee-jerks are usually exaggerated, though in a few cases they are said to have been diminished. The two sides of the body usually present the same abnormal increased reflex activity. Ankle clonus is a rare symptom.

Sensory Symptoms.—The sensory symptoms often resemble those observed in traumatic neurasthenia or hysteria but are less prominent. Pain is not a marked symptom in these cases. There is usually some pain in the back, and the spines may be sensitive on pressure, but the terrific pain and hyperesthesia complained of in the other neuroses is not present. Slight headache is a fairly constant symptom.

Anesthesia is often present but differs from the anesthesia of hysteria.

In extent, distribution, and selection it resembles the loss of cutaneous sensibility such as is found in the depressive and demented forms of insanity, more closely than the typical loss of sensibility commonly occurring in hysteria.[2]

Often there is no anesthesia but blunting of the general sensibility, slight touches anywhere upon the skin are scarcely noticed, while a needle prick causes only slight pain. In some cases the tactile sensibility is preserved while there is a local or general absence of the sense of pain. In the areas where sensibility is diminished, actual anesthesia is scarcely found, nor are the limits of these areas so sharply marked as is the case in hysteria.

[1] Bailey, *loc. cit.*, p. 515.

[2] *Ibid.*, p. 519.

Special Senses.—There may be inequality of the pupils, and even failure of the pupils to contract when exposed to light. The behavior of the eye reflex is quite different from that observed in neurasthenia where the pupils respond quickly to light, dilating and contracting alternately. Diminution of the visual fields has occasionally been recorded.[1]

Partial deafness on one or both sides is not uncommon. Subjective sensations of ringing and buzzing in the ears are not infrequent.

General Symptoms.—After a time these patients come to look severely ill. The features are pinched and drawn, the complexion takes on a grayish pallor such as is often seen in severe chronic forms of nervous disease. The appetite is poor, the bowels are constipated, dyspeptic symptoms are common. The patients may become anemic and considerably emaciated. They sleep badly, and are disturbed by horrible dreams and nightmares. The pulse is often unduly rapid. The sexual power in males is often lost.

Diagnosis.—The diagnosis of this group of cases is not always easy. It depends upon the ability of the examiner to exclude organic forms of injury or disease. In a general way it may be said that for the correct diagnosis of these cases the skill and experience of a highly trained neurologist are necessary, and the patient must be kept under observation for a considerable length of time.

Prognosis.—The prognosis as to cure in these cases is very bad. Very few of these individuals are ever able to resume an active occupation. In some the symptoms reach a certain grade of severity and remain unchanged. Others become insane and die lunatics. Still others live for an indefinite time and then die without developing any special symptoms other than those already described, their symptoms growing progressively worse and worse.

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[1] Bailey, *loc. cit.*, p. 520.

CHAPTER III

DISEASES OF THE SPINE

POTT'S DISEASE, TUBERCULOSIS OF THE SPINE, CARIES OF THE SPINE

Tuberculosis of the vertebræ is a very common disease. It may develop at any age, though most common between the ages of four and twenty years. Males are more often the victims than females.

Causation.—Here, as elsewhere, invasion of the tissues with the tubercle bacillus is the cause of the condition. As predisposing causes may be mentioned hereditary predisposition, depressed states of general health and malnutrition, resulting from acute diseases, or from unhygienic environment. Trauma is an undoubted cause in a certain proportion of cases; and yet, in a good many instances, a preceding fall upon the back, a blow or a strain, are assumed to be the cause of the disease, whereas, probably, they have had nothing to do with it.

Pathology.—The lesion consists of a tuberculous osteomyelitis, usually of the spongy portions of the bodies of the vertebræ, more often of the anterior portions of the bodies than elsewhere. The other parts of the vertebræ are rarely, although sometimes, attacked. As the result of the destruction of the bony framework of the body of the affected vertebræ, the bone becomes softened and is gradually crushed by the superincumbent weight. The collapse of the vertebræ causes an angulation at the point of disease, the upper portion of the vertebral column falling forward, so that at the point of angulation the spines of one or more of the vertebræ become prominent behind, producing the well-known deformity "humpback" or kyphosis. The infection is usually confined to one or more adjacent vertebræ; very rarely two separate portions of the spinal column may be simultaneously attacked. When the tuberculous process has run its course, the place of the diseased tissues is taken by firm new connective tissue and the deformity of the back remains permanent. Among the regular results, here as elsewhere, is softening and breaking down of the tuberculous tissue and the formation of a tuberculous abscess. Such abscesses tend to burrow in various directions according to the seat of the disease, and to approach the surface, forming the well-known tuberculous or cold abscess. These abscesses become superficial in different localities, according to the site of the diseased vertebræ. In the neck the abscess usually forms in the posterior wall of the pharynx, "retropharyngeal abscess." Such an abscess may project forward into the pharynx, or in some cases it will find its way between the

fascial plains of the neck and present below the ear beneath the sterno-mastoid muscle. When the disease is in the dorsal region the abscess may accumulate in the mediastinum; or may penetrate between the ribs and appear in the back to one side of the spinal column. In the lower dorsal and lumbar regions they follow down the course of the psoas muscle and appear above or below Poupart's ligament. In other cases they penetrate the loin above the crest of the ilium, at the outer border of the erector spinæ muscle, forming a lumbar abscess.

As the result of the displacement of the bones the spinal cord may be compressed, producing the symptoms of a compression myelitis. These symptoms vary in character according to the situation and degree of the compression. In the dorsal region the symptoms are those of spastic paraplegia—that is to say, the muscular power of the legs is diminished, the reflexes are increased. Total anesthesia of the extremities is rare, usually sensibility is merely diminished. There may or may not be partial or total paralysis of the bladder. Pain due to compression of the cord may be felt in the back or radiate downward in the back from the seat of disease. If the compression increases and is unrelieved, there will be atrophy of the muscles and in the later stages bed-sores; and if the patient has been catheterized, cystitis, etc. In some cases the disturbances in the function of the cord are due to involvement of the external surface of the dura mater, by the tuberculous inflammation. The cord is then compressed by edematous swelling of the surrounding structures and by inflammatory thickening. Other causes of disturbance of function are the pressure of a tuberculous abscess within the spinal canal, and in other cases embolism of the spinal vessels is said to be a cause. In advanced cases there is also a descending and ascending compression myelitis.

Symptoms.—In a certain proportion of cases the onset of the symptoms is preceded by an injury, not usually severe, to the back; and such injury may have occurred some months before the trouble with the spine becomes manifest. The early symptoms consist usually in deterioration of the general health; the children become languid, they suffer from loss of flesh and strength, are easily fatigued, and sleep badly. If carefully observed, it will be noted that when standing or sitting the child supports itself by the arms on tables and chairs. They walk rather stiffly, *rigidity of the spine* being one of the most characteristic symptoms. The gait and attitude of these children is peculiar and characteristic, but varies somewhat, according to the region attacked. In walking, the spine is held quite straight and rigid. When rising from a chair or in picking up an object from the ground the patient does not bend the back, but holds it stiff and straight. Sudden increase of pressure upon the diseased vertebræ being extremely painful, all the motions of the body are made slowly and carefully. In walking, the child places its feet with care to avoid any sudden jar and bears most of the weight upon its toes. In disease of the cervical region there may be a rigid deformity resembling torticollis. In other cases the head will be more or less markedly flexed or extended. There is in these cases also a forward flexion of the lumbar spine, so that the normal lordosis is diminished or absent.

In disease of the dorsal region the shoulders are elevated, and in disease of the lumbar region, during its earlier stages, the normal lordosis is increased. Some lateral deviation of the spine may be present in any case, no matter what the situation of the tuberculous process.

Pain.—Pain is an early and constant symptom of Pott's disease. It is usually referred to the distribution of the peripheral nerves arising from the cord at the level of the disease. In disease of the cervical region the children have pain at the back of the neck or below the occiput. In the dorsal region the pain is referred to the chest or, when the disease is lower down, to the abdomen. This last (abdominal pain) is present in a large proportion of cases, and may give rise to the belief that the child is suffering from trouble with the stomach, the intestines, or other abdominal organs. There may also be pain in the back, referred to the affected vertebræ, greatly increased by pressure over the spines whose bodies are the seat of disease and by motion. In the cervical region there may be disturbances of respiration, cough, dyspnea, and a jerky breathing, accompanied by grunting sounds during expiration. In this region, also, affections of the eye are sometimes observed—atrophy of the optic nerve, or neuritis, with dilatation of the pupils. In some of the more acute cases there is an elevation of temperature and a corresponding acceleration of the pulse.

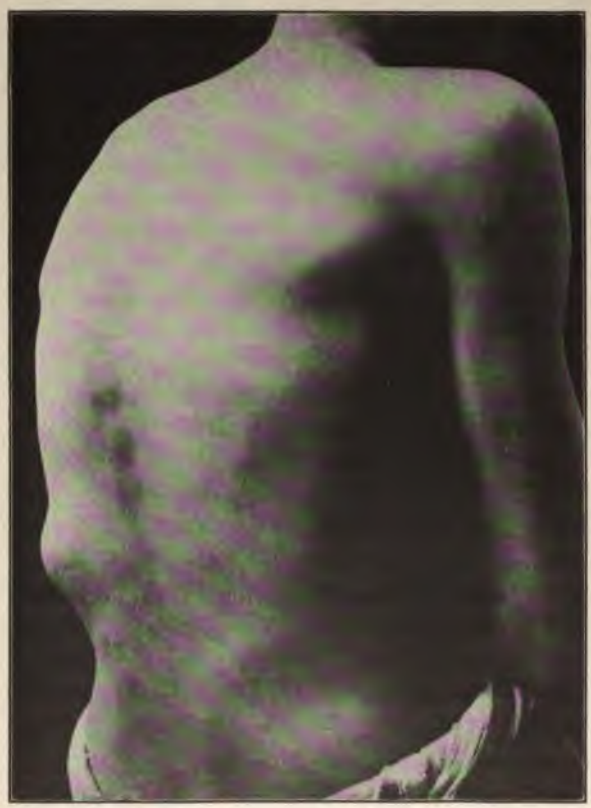

Fig. 27.—Tuberculosis of the Bodies of the Dorsal Vertebræ; Cold Abscess in the Back; Duration of the Disease One Year. (New York Hospital collection.)

Deformity.—The most characteristic sign, when the disease is fairly well advanced, is the deformity caused by the crumbling and collapse of the bodies of the affected vertebræ, producing a prominence of the spines in the back at the level of the disease and angulation of the vertebral column. At first, and in the more acute cases, this angular deformity is quite sharp. In the later stages it becomes more rounded. The *kyphus,* or hump, is most marked in the dorsal region, where the spine is

normally convex backward; less so in the cervical and lumbar regions, where the spine normally exhibits a forward curvature. For the purpose of record in the individual case it is important to preserve, from time to time, a tracing of

FIG. 28.—PSOAS ABSCESS SHOWING FLEXION OF THE FEMUR UPON THE PELVIS. Extreme lordosis was produced when the attempt was made to extend the thigh. Tuberculous caries of the lower dorsal vertebræ. (New York Hospital, author's case.)

the angular deformity of the back. For this purpose one may use a strip of lead or other soft metal, of suitable thickness, which is applied to the back and the outline of its various curves subsequently traced on paper.

Abscesses.—The signs and symptoms of tuberculous abscesses, secondary to disease of the vertebræ, resemble those of so-called "cold abscess," wherever situated. The signs and symptoms of acute inflammation are wanting—namely, pain, heat, redness, and tenderness. A moderate rise of temperature in the evening is not uncommon. Leucocytosis is either absent or slight, unless the skin is perforated and the walls of the abscess cavity are invaded by the pyogenic cocci. When the abscesses approach the skin, so that they become palpable, they give the ordinary sign of the presence of fluid collections—namely, fluctuation. If the abscess is about to perforate, the overlying skin becomes shiny, thinner, slightly reddened, and finally purple. The contents of the abscess consist of creamy, so-called tuberculous pus, mixed with cheesy material.

The local signs produced vary in different cases, according to their situation. In the cervical region a retropharyngeal abscess gives rise to difficulties in swallowing, sometimes to serious dyspnea. If the abscess finds its way laterally and presents at the side of the neck, a localized, rounded, fluctuating swelling is formed, with the absence of the signs of acute inflammation. In all cases fever is either slight or absent, unless pyogenic infection occurs, when septic symptoms will be developed. A large abscess in the mediastinum will give rise to pressure symptoms, sometimes of an alarming character—namely, dyspnea and cyanosis. A psoas abscess gives the signs of a tense, elastic tumor in one or other lower lateral quadrant of the abdomen. If it finds its way below

Poupart's ligament, the communication between the abdominal tumor and the swelling of the thigh may often be readily made out by palpation. Pressure upon the abdominal swelling increases the tension of the swelling in the thigh, and *vice versa*. In some cases a psoas abscess will present posteriorly upon the buttock. Those abscesses which follow the course of the psoas muscle are attended at first by limitation of motion in the hip-joint and later by a gradually increasing flexion of the thigh on the affected side, which cannot be overcome. It is usually easy to differentiate these abscesses from tuberculosis of the hip-joint by the presence in the former of an intra-abdominal tumor and by the signs of deformity of the spine (kyphosis) in the dorsal or lumbar regions, respectively. The paralyses which may accompany tuberculosis of the vertebræ have already been described.

FIG. 29.—PERINEPHRITIC ABSCESS PRESENTING IN THE BACK, SIMULATING AN ABSCESS CONNECTED WITH THE SPINE. (Author's collection.)

Diagnosis.—It is often possible to make a probable diagnosis of tuberculous disease of the vertebræ by watching the motions, attitudes, and general behavior of the patient. If the patient is a child, it may at once be observed that, so long as the child is lying down or is held in the arms in such a position that the weight of the body does not compress the diseased vertebræ, it will remain quiet and appear to be fairly comfortable. When placed in the upright posture, however, the child will immediately begin to cry. For purposes of examination these patients should be stripped naked. The rigid, stiff condition of the spinal column will be immediately noticeable. In case the disease is far enough advanced, the deformity of the vertebræ may be recognized at a glance if situated in the dorsal region. In the cervical and lumbar regions this deformity will be less marked. In the cervical and lumbar regions the immobility of the spine is usually a striking symptom. One of the simplest ways of detecting the presence of rigidity of the spine, as well as its locality, is to place the patient prone on the examining table and by lifting the legs and thighs off the table, to observe the behavior of the different portions of the spine. As the

patient is lifted from the table the affected portion of the spine will be seen to remain absolutely rigid. If the disease is in the lumbar region, the muscles of the back will be thrown into spasmodic contraction. If the disease is in the cervical region, the rigid position of the neck is striking, even upon casual observation. In any case, if the patient is seated upright, downward pressure upon the crown of the head will cause expressions of increased discomfort and pain. If the position of the head be that of torticollis, the examination should always include inspection and palpation of the cervical spines and an examination of the pharynx and lateral regions of the neck for the presence of abscess. In advanced cases an X-ray picture is often a valuable aid in diagnosis. Such a picture will often show actual loss of substance in the bodies of the affected vertebræ, or, if the vertebra has not actually crumbled, the outline and detail of bony structure may be hazy and obscure. It is to be remarked, however, that in very early cases the X-ray picture may be negative.

Differential Diagnosis.—The disease with which tuberculosis of the vertebræ is more likely to be confounded than with any other is one first recognized by Schede and later more precisely described by Kümmel. In this condition an injury has always preceded, usually of a fairly severe character, such as might have produced a fracture of the vertebræ. Whether an actual fracture has occurred in all cases, but has passed unrecognized, is not absolutely certain. In a few cases the preceding violence has been comparatively slight. At first the patient suffers from the immediate effects of the injury. These gradually subside, and the individual may appear to be quite well. After an interval, which varies in different cases and may be as long as a year or more, there is a return of pain in the back, usually accompanied by radiating pains following the course of the peripheral nerves. In addition, there develops a *kyphus*, an angular deformity, more or less sharp, according to whether one or several vertebral bodies are involved. Symptoms of compression of the cord are present in some cases, absent in others. In some of these patients a considerable interval occurs between the recovery from the immediate effects of the accident and the onset of the symptoms of the *rarefying osteitis*. In other cases the interval is short, or the immediate symptoms of the injury may gradually merge into those of the disease of the vertebræ. In general, it may be said that the *kyphus* is more rounded and less sharp than is the case in Pott's disease. If the patient is suspended, the general angular deformity disappears, but the spine of one vertebra still remains prominent. Abscesses do not develop. The prognosis of this condition is better than in Pott's disease. Under suitable treatment, these patients usually recover after a certain time, usually many months, and may be able to resume work. Deformity of a certain degree is, however, permanent. The affection of the joints of the spine sometimes following typhoid fever, and known as "typhoid spine," may be hard to differentiate from Pott's disease. Time, the X-rays, the absence of deformity, and the history of recent typhoid or the presence of a Widal's reaction may aid in the diagnosis. Pediculi of the scalp, with inflammatory enlargement of the cervical lymph nodes, will occasionally

be confounded with early disease of the cervical vertebræ, as may be other acute inflammatory affections of the neck. Malignant disease of the spine may very closely simulate Pott's disease. The progress of the case, the agonizing, spontaneous pain due to pressure upon the posterior nerve roots in malignant disease, the X-ray, the development of metastatic tumors, are aids in the diagnosis. The age of the patient also may be significant, most of the cases of Pott's disease occurring in children and young adults. Arthritis deformans of the vertebræ occurs for the most part in those advanced in years. (See Arthritis Deformans of the Spine, page 83.) The pain and stiffness of the spine closely resemble Pott's disease. The development of a *kyphus* is absent. Lateral curvature of the spine is a condition of slow development and is attended by a more or less characteristic deformity, which ought not to be confounded with tuberculosis. (See Scoliosis.) Conditions which might rarely be confounded with Pott's disease are aneurysm of the aorta, syphilis of the vertebræ, actinomycosis, and osteomalacia of the spine.

Prognosis.—The prognosis of Pott's disease, both as to life and permanent deformity, is greatly modified by the previous condition of the patient, by hygienic or unhygienic surroundings, by early and skillful treatment, and, to some extent, by the situation of the lesion. In the cervical and lumbar regions the prognosis is more favorable than in the dorsal region.

SCOLIOSIS (LATERAL CURVATURE OF THE SPINE)

Scoliosis is a very frequent affection. It may be congenital or acquired. It is in general a disease of childhood and youth. Although observed with almost equal frequency in both sexes, the severe cases, which require special treatment, are much more often seen in girls than in boys, presumably because male children are usually more active, take far more exercise, and in them the condition is less likely to develop to a serious degree. About one half the cases develop between the ages of seven and ten years. From the point of view of causation, lateral curvative of the spine may have a number of origins. The rarest form is congenital, and is due to some intra-uterine defect of development. It has been observed combined with congenital dislocation of the hip. In other cases it is observed as a part of achondroplasia, and may accompany spina bifida. In a few cases unequal development of the two sides of one or more of the bodies of the vertebræ has been demonstrated by an X-ray picture.

Rachitic Scoliosis.—Lateral curvature of the spine when observed in early childhood is usually due to imperfect ossification of the skeleton, and is probably developed from improper methods of carrying and handling the child during infancy. Children are habitually carried upon the left arm in such a manner that the spinal column tends to be bent into a curve convex toward the left. In these cases the middle portion of the spinal column is first affected, —namely, between the dorsal and lumbar regions. Such a deformity readily becomes habitual, and when the rachitis is cured the curvature remains permanent.

Static Scoliosis.—In this form the lateral curvature of the spine is compensatory, and depends upon a congenital or acquired shortening of one lower extremity. After a time the deformity of the spine tends to become permanent. It is therefore important in examining a case of scoliosis to make comparative measurements of both lower extremities. Scoliosis may also develop as the result of contraction of one half of the thorax, as the result of injury and extensive scarring, not infrequently as the result of empyema, in which the lung does not reëxpand. In cases of disease of the spinal cord in children (poliomyelitis anterior), with paralysis affecting only one half of the body, lateral curvature of the spine may develop. In chronic cases of sciatica a moderate lateral curvature of the spine is often observed.

Habitual Scoliosis.—Far more frequent than any of the forms already mentioned is the so-called habitual scoliosis. It develops most often between the seventh and tenth years of life and affects girls five times as frequently as boys. The most probable explanation of the occurence of the deformity seems to be that, by improper positions while studying, and especially while writing in school, children acquire the habit of keeping the spinal column always bent in one direction. The most frequent type of deformity is that the spine is bent in the lumbar region in a curve convex toward the left and in the dorsal region convex toward the right. In addition to these lateral curves, there is a rotation of the spine upon a vertical axis; the bodies of the vertebræ are rotated toward the convex side of the lateral curve. In addition, there is usually some change in the antero-posterior curves of the spinal column, the most common being an increased or diminished dorsal curvature. As the result of the constant maintenance of an abnormal position, the bones of the spine and the ribs, the ligaments and the muscles of the back, develop in an abnormal way. The bodies of the vertebræ are not symmetrical. They become thinner on the concave side of the curve and thicker upon the convex side. The intervertebral discs suffer a similar change and undergo partial atrophy from continued pressure. The ligaments of the spine become shortened on the concave side, lengthened on the convex side, of the curve.

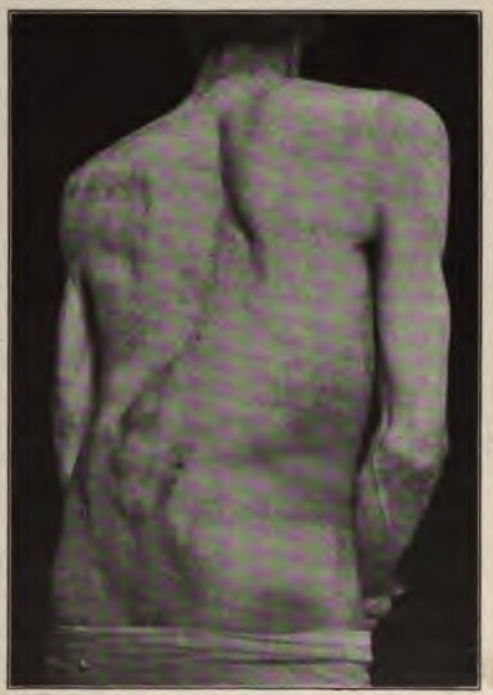

FIG. 30.—SCOLIOSIS OF THE COMPOUND TYPE OBSERVED IN A LETTER-CARRIER. (New York Hospital, service of Dr. F. W. Murray.)

The muscles of the back become, respectively, shortened and lengthened on the two sides of the body. Accompanying these changes there are corresponding deformities of the ribs and pelvis. The thorax upon the concave side is diminished in capacity, the lung is more or less compressed, and most of the breathing is done with the lung of the opposite side. Various displacements and deformities of the stomach, the liver, and other abdominal viscera may gradually develop.

Symptoms and Diagnosis.—From the point of view of diagnosis and treatment, it is important to distinguish between the cases in which the deformity remains merely habitual, without any profound organic changes in the bones and ligaments of the spine, and those cases in which such changes have already taken place, and the deformity has thus become more or less permanent. In the first group there is usually a curve of the entire spinal column, convex to the left. The child habitually carries its shoulders in the so-called "round-shouldered" position. The left shoulder is higher than the right. If we stand behind the patient and direct him to bend forward at the hips so that the body is nearly horizontal, the right half of the back appears to be more prominent than the left. In examining such a patient we may trace upon the skin with a suitable pencil the line of the spines of the vertebræ. By comparing this line with a plumb line hung through the cleft between the buttocks we may readily detect a lateral curvature of the spine if such be present. If the spinal curvature has not as yet produced any marked structural changes, suspending of the patient in Sayre's apparatus will usually cause obliteration of the spinal curve. When no such changes have taken place, the prognosis as to cure is good, under suitable treatment. In the cases where structural changes have already developed there may be but one lateral curve; more commonly there are two—that is to say, a curve in the lumbar region, convex to one or other side, and a compensatory curve in the dorsal region, convex in the opposite direction. These curves do not disappear when the patient is suspended, thus showing that actual deformity of the bony and ligamentous structures is present. In these cases inspection will show a change in the size and shape of the two halves of the thorax. The chest and back upon the side of the convexity of the lateral dorsal curve are always more prominent and better developed than upon the opposite side. In these cases, also, rotation of the spine is present, and is most readily detected by standing behind the patient and causing him to bend forward so that the back is horizontal. The rotation is toward the convexity of the lateral curve. Upon the convex side of the curve the shoulder-blade is raised by the underlying ribs and becomes more prominent. It is also further removed from the median line of the back, whereas upon the concave side the shoulder-blade approaches more nearly to the spines of the vertebræ. In severe cases the assymmetry of the entire skeleton of the trunk is so marked as to be patent to the most superficial observer. In the diagnosis it is important that these cases should be recognized at the earliest possible moment, and where a parent comes, stating that a child has one shoulder higher than the other or one hip more prominent than the other, the clothing should be removed and a careful examination made

of the spine for evidences of scoliosis. When the curvature is chiefly in the lumbar region the most noticeable deformity in the beginning is that one hip appears to be higher than the other. If the lumbar curve is to the left, the right ilium is unduly prominent and the left lumbar region is more prominent posteriorly than the right. The general symptoms accompanying severe grades of scoliosis may be a general impairment of health, disturbances of digestion, a tendency to pulmonary disease, shortness of breath on exertion, and, in the most severe cases, intercostal neuralgias due to pressure upon the posterior nerve roots where they are compressed upon the concave side of the curve. The ribs may even be so far depressed as to come in contact with the crest of the ilium, and thus cause pain. Every case of lateral curvature of the spine requires careful treatment, inasmuch as it is impossible to know in the given case whether the deformity is likely to remain stationary or to grow slowly worse.

ACUTE OSTEOMYELITIS OF THE SPINE

The spinal vertebræ are among the rarer locations of acute suppurative osteomyelitis. It is so rare that clinical records exist of less than one hundred cases. Hahn collected forty-one cases in 1900. As in other bones, acute osteomyelitis is a disease of youth. Seventy-five per cent of the cases occur before the twentieth year of life. The disease affects boys much more often than girls. The lumbar vertebræ are most often attacked, the cervical region least often. While the bodies of the vertebræ are the most common seat, any portion of the bones may be affected. The foci may be small and solitary, or multiple, or in other cases the entire body of the vertebra may be infiltrated with pus. Sequestra, if formed, are usually small, though a considerable portion of a vertebra may undergo necrosis. There has been a history of injury in a large proportion of the cases. The staphylococci are usually present in the pus. The disease commonly ends in abscess, although suppuration may be absent in subacute and chronic cases. When abscess formation occurs, the pus may burrow in a number of directions—into the intervertebral joints, into the spinal canal, or, if the bodies of the vertebræ are attacked, abscesses may be formed in the pharynx, in the mediastinum, often with secondary involvement of the pleural sac; or, if the lower vertebræ be attacked, a psoas abscess may follow. When the disease attacks the arches and posterior portions of the vertebræ the abscess usually makes its appearance on the back. A serious element of danger exists, in that the spinal canal may be entered by the pus, producing sometimes pressure symptoms, in other cases meningitis, in still others myelitis. In some cases pressure symptoms upon the nerve roots have been observed, and the localization of the resulting neuralgia may be an aid in the diagnosis. Thus, in osteomyelitis of the sacrum there may be an intense sciatica.

Symptoms.—The symptoms of osteomyelitis of the vertebræ are in part those of osteomyelitis in general, as already described (see Osteomyelitis), and in part local symptoms, depending upon the situation of the process. In the

more severe cases the intense septico-pyemia, with its typhoid condition—stupor, delirium, coma, etc.—will often obscure the diagnosis. In the less severe cases the diagnosis will depend largely upon the portion of the vertebræ involved and upon whether, as a consequence, the pus burrows forward or backward. In all cases there is pain and tenderness posteriorly over the spines of the vertebræ in the region of the spine affected; in some cases distinctly localized, in others more diffuse. As in tuberculosis of the vertebræ, pressure upon the crown of the head downward causes an increase of the pain. If the pus burrows backward, there may be formed, in from three to ten days, an inflammatory edematous swelling in the back, frequently diffuse, which, if the patient survives, will give, sooner or later, definite signs of the presence of pus. If the body of a cervical vertebra is the seat of the disease, the pus may form a retropharyngeal abscess, palpable through the pharynx. If the dorsal vertebræ are involved, the diagnosis is much more difficult. There will then be, in addition to the pain and intense septic symptoms, little to indicate the anatomical seat of the process, unless the abscess breaks into the pleura with the production of an empyema. If the lower dorsal or lumbar vertebræ are involved, a psoas abscess may be formed, though in both the last two groups of cases it is more common for the patient to die from septic poisoning before the abscess can be recognized by its own physical signs. If a psoas abscess forms, it is to be recognized by the signs already described under Tuberculosis of the Vertebræ, except that in the condition under consideration all the symptoms are those of an acute inflammatory process. In many of these cases the diagnosis has been made of typhoid fever or of peritonitis. In the cervical region, if the spinal canal is involved, there will be the symptoms of basilar meningitis—namely, stiffness of the muscles of the neck, headache, stupor, delirium, coma, and death. If the lower vertebræ are involved, there may be symptoms of compression of the spinal cord, of myelitis, or of compression of the nerve roots.

Prognosis.—The mortality of all cases is about sixty per cent, and depends for its gravity chiefly upon the pyemia which frequently accompanies the condition and upon the frequent involvement of the cord and its membranes. When the disease involves the posterior portions of the vertebræ and the pus burrows backward the prognosis is naturally much better than when it follows an opposite course. The earlier the condition is recognized and is subjected to operative treatment, in case the focus of suppuration is accessible to the knife, the better the prognosis.

SPONDYLOLISTHESIS

By the above title is designated an extremely rare condition, much more frequent in women than in men, and characterized by a slowly progressive separation between the last lumbar vertebra and the sacrum, resulting finally in a more or less complete dislocation forward and downward of the vertebra above from the vertebra below. The disease has been referred to rachitis and to trauma. The appearance in well-developed cases is peculiar. The trunk ap-

pears shortened and looks as though it had descended into the pelvis. There is a very marked lordosis in the lumbar region, and upon vaginal palpation a marked projection forward and downward can be felt, consisting of the bodies of the dislocated lumbar vertebræ. The center of gravity of the trunk is changed and displaced forward; there is inability to extend the thighs fully, and the patient may have some difficulty in walking. An accurate diagnosis might be made by means of the X-rays.

SPONDYLITIS DEFORMANS (ARTHRITIS DEFORMANS OF THE SPINE)

Several conditions, more or less resembling one another, are probably best included under this head. They all depend upon a chronic inflammation of the parts entering into the joints between the spinal vertebræ. In some of them the changes characteristic of arthritis deformans have been discovered at autopsy and some of them have been associated with arthritis deformans in other joints. In some the lesion has seemed to be rather a sclerosis of the ligaments and other soft structures joining and surrounding the verebræ. They all have this in common, that usually, combined with more or less severe pain of a chronic character on moving the back, the spine becomes either locally or generally more and more stiff, immovable, and rigid. The affection is one which is more common in men and rare during the earlier decades of life. There seems to be a fairly marked hereditary predisposition. I have known several families in which father and son were both successively affected. The patients are rendered extremely uncomfortable from inability to bend the back and from pain. Nervous symptoms are usually absent. The course of the disease is extremely slow, but tends to be steadily progressive. In cases where only a portion of the intravertebral joints are involved the patients may be fairly comfortable and may be unconscious of the rigid condition of a portion of the spinal column. Usually there is a marked bending of the whole spinal column forward, so that the dorsal curve is exaggerated and the normal lumbar lordosis is diminished or absent. The diagnosis in well-advanced cases, and especially if other joints are involved, is very easy. If, on the other hand, the spinal column merely is the seat of the disease and the patient presents himself before the back has become entirely rigid, it may not be so easy; but the steadily progressive tendency of the disease, together with the absence of improvement under any form of treatment, will, after observation for a considerable period, enable the surgeon to make a definite diagnosis. (See Chronic Disturbances of Joints, Chapter VIII.)

SYPHILIS OF THE SPINAL VERTEBRÆ

Although one of the rarer sites of syphilitic inflammation, syphilis of the bones of the spinal column does occasionally occur, and its diagnostic importance depends largely upon the fact that it so closely resembles tuberculosis of the spine that a differentiation is often extremely difficult. The process is in the

nature of a gummatous infiltration of the bone, usually followed by necrosis. The lesion is only rarely developed during the earlier stages of the disease and in most instances is postponed for years after the occurrence of the primary lesion. In a few instances early syphilitic ulcerations of the pharynx have invaded bodies of the vertebræ, but such an accident is extremely rare. The cervical region is the favorite site of the disease, and the uppermost vertebræ more often than those lower down. One or several vertebræ may be attacked. If, as is usual, the process ends in necrosis, portions of dead bone may ulcerate into the pharynx, separate, and be discharged through the mouth. The other portions of the spinal column are occasionally the seat of the disease.

Symptoms.—The symptoms very closely resemble those of tuberculosis of the vertebræ, nor is a differential diagnosis always possible. There is pain and, in advanced cases, deformity, resembling that seen in tuberculosis, and sometimes pressure symptoms upon the spinal nerve roots and upon the cord. The pain is often extreme; it is increased by pressure and by movement; but it is said not to be so constant as is the case with tuberculosis. It is usually more severe at night, and may vary in intensity with weather conditions. In general, the physical signs very closely resemble those of tuberculosis, except that the formation of abscesses is rare indeed in syphilis. The presence of other tertiary syphilitic lesions, the benefit derived by the use of iodid of potash internally in suspected cases, the absence of abscesses, or even a syphilitic history, may aid in the diagnosis. The age of the patient is often significant. Tuberculosis, though it may occur at any period of life, is much more common in childhood and youth, whereas syphilis of the vertebræ very rarely occurs before full manhood and may be delayed until an advanced age. Wassermann's reaction may be tried.

ACTINOMYCOSIS OF THE VERTEBRÆ

The bones of the spine are a rare location for the ray fungus. In the cases where it has been observed the infection has commonly occurred through the mouth, the esophagus, or the stomach; occasionally the lungs. Since the disease usually develops in the mediastinum, it commonly spreads upward and downward, involving the bodies of a number of vertebræ. The bones are destroyed in such a way that they appear as if worm-eaten. Collapse of the body of a vertebræ, with the formation of a kyphosis, has never been observed. In a certain proportion of cases the rather characteristic boardlike infiltration of the tissues appears upon the back and is here associated with a marked boggy edema. Upon incision, but little pus escapes as a rule; the characteristic granules may be identified under the microscope. In the cases which have been observed, symptoms referable to pressure upon the nerve roots have been more marked than those indicating compression of the spinal cord. In most of the cases the diagnosis of actinomycosis has been made by the discovery of the characteristic masses of fungus in the sputum, in vomited material, or in some other way, before the symptoms of invasion of the spine have been present.

TUMORS OF THE SPINAL VERTEBRÆ

Varieties.—Tumors of the spinal vertebræ are not rare. Ninety per cent of them are malignant, carcinoma and sarcoma. Probably all carcinomata of the spinal vertebræ are secondary tumors. Sarcomata, on the other hand, are more often primary than secondary.

Carcinoma.—Carcinoma of the vertebræ is more frequent in females than in males. The most common sites of the primary growths in females are the female breast and the uterus. While a large proportion of carcinomata are metastatic, a considerable number involve the vertebræ by direct extension from neighboring organs—the esophagus or the stomach, for example. Carcinoma most often affects the vertebræ of the dorsal and lumbar regions. The growth is of the infiltrating type. When the tumor is metastatic, foci of cancer develop in the spongy tissue of the body of the bone and spread until the entire body of the vertebra is destroyed, with the exception of a thin outside layer of bony tissue. In some cases but one vertebra or several adjacent vertebræ are involved. In other cases, metastatic tumors form in many vertebræ, so that before the patient dies, the entire length of the spinal column may be the seat of cancer. When the bones have become sufficiently weakened, collapse of one or more of the vertebral bodies may take place, either suddenly, as the result of some slight injury, or of some sudden movement, or gradually. In the first instance, the infiltrated vertebral body suddenly gives way with the formation of an angular deformity of the spine and the production of a *kyphus*. In some cases the angle made by the two segments is sharp; in others, where many bones are softened and collapse, the angular deformity produced is not so sharp and the kyphosis is more rounded. Carcinoma usually remains confined to the bones themselves for a long period, assuming that the disease is metastatic and not a direct extension from a carcinoma in the vicinity of the spine, the spinal canal is, therefore, invaded in most cases quite late, if at all. In some cases the cord is, however, compressed by tumor masses, and usually the nerve roots suffer from pressure at a comparatively early period. The displacement of the collapsed vertebræ may cause pressure symptoms due to the narrowing of the spinal canal.

Sarcoma.—As stated, primary *sarcoma* of the spine is not very rare, though many cases are due to extension of sarcomata originating in the neighboring viscera, or in the ribs, or in the muscles. All the different varieties of sarcoma have been observed in the spine, both as primary and as secondary growths. Whereas in carcinomata a palpable tumor is rarely produced, in sarcomata, tumor masses in the vicinity are often formed, even when a growth is primary in the vertebræ; such that they may be accessible to vision and palpation, or give pressure symptoms by involvement of neighboring organs. Sarcoma of the vertebræ is, if possible, even more malignant than carcinoma. This is true, especially of melanotic sarcoma. I have seen two cases in which a section of the entire spinal column had been made at autopsy and where the sawn sur-

faces of the vertebræ looked as though they had been rubbed with lampblack, so universally diffused was the growth of tumor tissue. The sarcomata tend to invade the spinal canal earlier than do carcinomata, and to involve the dura and the cord itself. In some cases the spread of sarcoma outside the vertebræ is very extensive, so that large tumor masses may make their way to the surface posteriorly, and even ulcerate.

FIG. 31.—MYELOMA OF THE SPINE.
(New York Hospital, case of Dr. L. A. Stimson.)

MYELOMA.—Myeloma, a tumor composed of tissue resembling the red marrow of the bones, may occur in the vertebræ as in other bones. Large tumor masses may be produced. See Fig. 31 of a case of myeloma observed in the New York Hospital. The patient was under the care of Dr. L. A. Stimson. The myelomata cause considerable destruction of the vertebræ. They form tumor masses of considerable size and produce, when the vertebræ involved collapse, a deformity of the back, as in other cases. The cord is compressed either by the tumor itself or by the displaced bones. Although myeloma is a benign growth, it occurs with multiple localizations and in the spine, ends fatally. Albumose is found in the urine. It was observed in eleven out of nineteen cases collected by Thomas.

The following is a brief abstract of the history of a case of myeloma of the spine observed in the New York Hospital in the service of Dr. L. A. Stimson. The patient was a man, aged fifty, who first came to the hospital in October, 1903. In June of that year he began to suffer pain in the small of the back and to notice that the muscular power in his legs was diminished, so that he walked unsteadily. His general condition at this time was good. The following local signs and symptoms were observed: There was a band of hyperesthesia surrounding the body, extending from the level of the fifth to the tenth dorsal vertebræ. There was some diminution of tactile sensibility in both legs. On October 24th he was operated upon, and the laminæ of the seventh and eighth dorsal vertebræ were removed on the left side. The bones were softened, and some soft tissue, resembling granulation tissue, was removed from between

the transverse processes of the vertebræ. Under the microscope this tissue was found to resemble bone marrow, and the diagnosis of myeloma of the spinal vertebræ was made. The patient recovered from the operation and left the hospital. In March, 1904, he returned, complaining of severe pain in the abdomen and thighs. The painful area was hyperesthetic. The reflexes in the lower extremity were exaggerated. The patient walked with a shuffling gait. In October, 1904, he was suffering from extreme pain referred to the course of the lower intercostal nerves and in the lower portion of the dorsal region of the back. Although the muscular power of his legs was diminished, there was no total paralysis and he was still able to walk, though with great difficulty. Movements of the spinal column, coughing and sneezing, caused marked increase in the pain. On November 9, 1904, he was again operated upon; the transverse processes of the seventh, the eighth, and the ninth dorsal vertebræ were removed upon the right side. The bodies of these vertebræ were found softened, and a tumor mass as large as a walnut was removed from the spinal canal. His symptoms were not improved by this operation, and three months later both legs were totally paralyzed, with exaggerated reflexes. In September, 1905, he returned to the hospital. There was loss of motion and sensation in both lower extremities. The anesthesia extended upward as far as a line one and a half inches above the navel. Above this there was a band of hyperesthesia four inches wide. There was complete loss of control over the bladder and rectum. At this time the diseased vertebral bodies had collapsed and a marked kyphotic prominence was present in the mid-dorsal region. To the left of the spinal column in the back there was a soft, semifluctuating swelling, evidently composed of tumor tissue. He died on November 15, 1905. The illustration (Fig. 31) is a photograph of a section of the spine at the seat of the disease.

Echinococcus Cysts.—Echinococcus cysts, though very rare, have been observed in the spine. They give rise to considerable tumor masses, which may cause absorption of the vertebræ, deformity, and pressure symptoms. A diagnosis is only to be made by microscopical examination of the contents of the cysts.

Bony and Cartilaginous Tumors.—Bony and cartilaginous tumors are not very rarely developed in the spinal vertebræ. Usually they are cartilaginous tumors which subsequently undergo ossification. They produce symptoms and become important only when they grow into the spinal canal and compress the spinal cord, or are so situated that they produce pressure upon the nerve roots.

A solitary case of *angioma* of the vertebræ was reported by Gerhardt. It produced a destructive total transverse lesion of the cord.

Symptoms of Malignant Tumors of the Vertebræ.—The symptoms of tumors of the vertebræ consist of two groups—namely, those produced by the lesions of the bones and those produced by pressure upon, or destruction of, the spinal cord and the spinal nerve roots. The signs and symptoms referable to the bone are chiefly two—pain and deformity. Localized pain and tenderness is usually present over the diseased vertebræ, although it may be entirely absent. In most cases the local pain is increased by motion and by pressure. Tenderness may be marked, or absent in some cases; while the spontaneous pain is very great. The tenderness may be most marked over the spines of the affected vertebræ,

or to one or the other side (Schlesinger). The deformity caused by the destruction of the vertebræ is present in some cases, absent in others. As already stated, sharp angular deformity is less apt to result from tumors of the vertebræ than is the case with tuberculous disease of the same. The deformity caused by tumors is more apt to be a marked exaggeration of the antero-posterior curve of the spinal column. The prominence in the back is rounded rather than angular. As stated, such deformity may occur slowly and gradually, or quite suddenly, when the softened bodies of the vertebræ give way and collapse. In addition to the deformity produced by displacement of the bones, there is, notably in sarcomata and in bony tumors of the vertebræ, a deformity caused by the presence of tumor masses. Such deformity may be palpable in the back, at the side of the neck, through the abdominal wall, in the pharynx, or may be felt *per vaginam* or *per rectum*, according to the situation of the tumor in different cases. As stated, the sarcomata may form, as well as the myelomata, large tumor masses, visible and palpable in the back; and in the case of the sarcomata these may even ulcerate through the skin.

Symptoms Due to Pressure Upon the Nerve Roots.—Probably the most marked and characteristic symptom of tumors of the spinal vertebræ are those due to compression of the sensory nerve roots. They consist of neuralgic pains, usually bilateral, and of fearful severity. In the earlier stages of the disease, the neuralgias may occur in attacks. The pains are referred to the areas supplied by the particular nerve roots affected. As time goes on, the attacks of pain become more frequent and more severe, and in the later stages pain of an agonizing character is felt continually, and is scarcely to be controlled even by large doses of morphine. Associated with the neuralgia there is often spasmodic contraction of groups of muscles. Motor paralysis is an infrequent symptom, although it may occur. The symptoms of irritation and compression of the sensory nerve roots are present in sixty per cent of the cases of malignant growths involving the vertebræ. Symptoms of *compression of the spinal cord* usually occur quite late in the disease, and are an omen of fatal significance. Life is usually prolonged only a few weeks after their appearance. The symptoms of compression of the cord are, paralyses of voluntary motion, together with disturbances of sensation. They are felt bilaterally, only rarely unilaterally, indicating in the latter case the involvement of but half of the cord. In some cases the symptoms of compression come on suddenly and are due to the displacement of the softened vertebræ and compression of the cord by the displaced bones. In these cases they are identical with the symptoms produced by fractures and dislocations of the vertebræ due to injury. In one case under my observation I had operated upon a woman for carcinoma of the breast. There was no local recurrence. One year later the patient returned to the hospital complaining of neuralgic pain in both upper extremities. There was a marked exaggeration of the normal upper dorsal and lower cervical curves, and the patient was not able to hold up her head, partly on account of the collapsed vertebral bodies, partly on account of muscular weakness, and partly on

account of the greatly increased pain when the erect posture was assumed. In the course of two months total paraplegia slowly developed and within six weeks thereafter the patient was dead.

Diagnosis.—The diagnosis of tumors of the spinal vertebræ is in some cases easy, and in others very difficult. In the cases of the benign tumors, whether bony or cartilaginous, the diagnosis may be made with a fair degree of probability, when symptoms referable to the bones, the nerve roots, and the cord are present, and we find bony or cartilaginous tumors in other parts of the body. The occurrence also of such symptoms, when we have the history of the removal of a malignant growth from some other part of the body, renders the diagnosis of secondary involvement of the spinal vertebræ exceedingly probable. In the absence of such a history we may for a long time be at a loss as to the diagnosis. We may not be able to find the primary tumor, since it may lie in a hidden situation. We are much more likely to mistake a malignant growth for tuberculous caries of the spine than for any other disease. This distinction is usually present. In *tuberculosis* of the spine *suspension* of the patient *relieves* or stops the pain. In *malignant tumors* of the vertebræ *suspension* usually makes the pain *worse*. From ordinary neuralgias and neuritis we may sometimes make the diagnosis after the case has been under observation for a time, from the fact that the pain grows worse under any form of treatment, that it is usually bilateral, and that its severity is usually greater than in ordinary affections of the nerves. In regard to the history of a primary growth, it is to be borne in mind that the involvement of the spine may occur many years after such a growth has been removed, and that the nature of the original operation and the character of the growth removed may be unknown to the patient. It is not always easy to differentiate between tumors of the vertebræ and tumors originating in the spinal canal itself, either in the cord or its membranes. The most important points to bear in mind in this connection are, the way in which the different groups of symptoms appear. In tumors originating in the bone symptoms referable to the vertebræ themselves may be, and often are, recognizable at an early date. Symptoms referable to the nerve roots commonly follow, and lastly, those referable to the cord. In tumors arising within the spinal canal, symptoms of irritation or compression of the nerve roots are usually first observed, later on cord symptoms, and symptoms produced by involvement of the bone appear later, or are absent. If we have a history of the removal of a primary growth, or if a primary growth is still present, the symptoms referable to the spine are probably due to involvement of the vertebræ rather than to direct involvement of the cord or its membranes. If there is no history of a primary growth and a tumor develops, evidently connected with the spinal vertebræ and visible or palpable as a considerable mass in the back, in the throat, or elsewhere, a diagnosis of *sarcoma* is probable. The prognosis of malignant tumors of the vertebræ is absolutely bad. According to the statistics of Schlesinger, the average duration of life in carcinoma of the spine after the first appearance of the symptoms is only nine

and one half months; in the case of sarcoma eleven months. The longest duration of life in carcinoma was three and one half years; in sarcoma, two and one half years. The prognosis of benign tumors, whether bony or cartilaginous, is, of course, far less gloomy. The tumors may cease to grow and yet, if symptoms of irritation of the nerve roots have once developed, they are apt to remain permanently.

INTRASPINAL TUMORS

Since, from a diagnostic point of view, we are usually quite unable to distinguish the pathological character of intraspinal tumors before exposing them by operation or autopsy; and since the symptoms produced are very largely due to pressure upon, or destruction of, the spinal cord and the nerve roots; and since inflammatory masses may produce identical symptoms with the true new growths, it is customary in discussing the diagnosis of intraspinal tumors to include localized inflammatory processes, syphilitic or tubercular granulomata, parasites, and other conditions causing definite symptoms of compression or destruction upon the cord or its nerve roots. Intraspinal tumors may be situated outside the dura, *extradural;* inside the dura, *intradural;* or within the cord itself, *intramedullary.* Such tumors are much less frequent than tumors of the vertebræ in the proportion of one to two. The following table, quoted from Schlesinger, gives a good idea of the characters and relative frequency of different forms of intraspinal growths.

TABLE OF SPINAL-CORD TUMORS

Variety.	Intradural.		Both.	Extradural.		Single.	Multiple.	Total.
	Medullary.	Meningeal.		Meningeal.	Not Meningeal.			
Sarcoma	14	53	9	17	11	80	27	107
Tubercle	62	..	..	2	..	55	9	64
Echinococcus	..	5	..	39	..	8	36	44
Fibroma	..	20	2	5	..	15	18	33
Gumma	7	4	15	2	..	19	9	28
Glioma	20	..	..	..	..	20	..	20
Psammoma	..	18	..	..	..	18	..	18
Myxoma	..	7	..	4	..	11	..	11
Lipoma	1	8	..	..	1	8	3	11
Cysticercus	2	5	..	..	1	4	4	8
Gliosarcoma	..	3	4	..	..	..	7	7
Endothelioma	..	5	..	1	..	4	2	6
Melanosarcoma	1	..	3	..	..	1	3	4
Neuroma	4	..	..	..	..	3	1	4
Lymphangioma	..	1	..	1	..	1	1	2
Cysts	..	1	..	1	..	1	1	2
Cholesteatoma	1	..	..	..	..	1	..	1
Uncertain	13	12	2	3	..	24	6	30
Totals	125	142	35	75	13	273	127	400

Among the intraspinal tumors, malignant growths are much more common than the benign, in the ratio of ten to one. Among these the most common extramedullary growth is sarcoma, and after that fibroma, endothelioma, myxoma, and lipoma are frequent in the order of mention. The lipomata are often associated with congenital defects of the spinal vertebræ (spina bifida). Woolsey observed one case of intraspinal neurofibroma with similar tumors elsewhere in the body, and a few other such cases have been reported. Among other extradural growths may be mentioned enchondromata, masses of tuberculous granulation tissue and tubercular abscesses. Parasitic cysts occur, both cysticercus and echinococcus cysts, the former being the more common. Nonparasitic cysts, dermoids, and localized collections of clear fluid in the subarachnoid space may occur and may produce more or less marked symptoms by pressure. Among the malignant growths carcinoma and sarcoma, as well as teratoma, may form metastases outside the dura. There tumors tend to spread up and down the spinal canal and very rarely perforate the dura, nor do they tend to compress the cord at an early date, so that the only symptoms observed for a long time may be those due to pressure on the nerve roots. Among the intradural tumors a considerable variety have been observed, as may be seen from consulting Schlesinger's table. Among the sarcomata nearly all the forms have been observed from those associated with fibroma and myxoma of slight malignancy, to the most malignant types. In some of the worst cases a general dissemination of sarcoma may occur in the pia mater, even as far as the interior of the skull. With the exception of these and the neuromata and neurofibromata, the tumors are usually solitary.

Syphilitic gummatous nodules may occur, or in other cases the process is more like a diffuse syphilitic meningitis. The gummata usually originate in the pia. The extradural and extramedullary growths rarely penetrate into the substance of the cord, since the pia seems to furnish a strong barrier against such invasion. The intradural growths develop for the most part behind, or behind and to one side, of the cord. They are frequently encapsulated, or at least can be separated from the cord and the dura without doing very serious damage to either structure. The tumors originating in the spinal cord itself are glioma, sarcoma, tubercle, gumma, and rarely cysticercus. The sarcomata and gummata are usually tumors which, having developed in the pia, perforate and involve the cord itself. The other forms originate in the cord.

The most frequent situation of intraspinal tumors is in the dorsal region and next in the cervical region.

Causation.—If we except syphilis, tuberculosis, and the metastatic forms of intraspinal growth, the causation of these tumors is usually obscure. In a considerable proportion of cases there has been a history of injury. They occur with the greatest frequency during the middle decades of life, the only exception to this being tuberculosis, which is, of course, more common in the young.

Symptoms.—The symptoms of intraspinal tumors may be divided into two groups: namely, those referable to the nerve roots and those referable to pressure upon, or destruction of, the cord. Symptoms referable to the spinal column

may, or may not, be present, but they are rarely significant in the diagnosis. When present, they consist of localized pain and tenderness on pressure. The symptoms of pressure upon the nerve roots are usually the first to appear in extramedullary growths. Since the tumors are usually situated posterior to the cord, the sensory nerve roots are the ones first affected, and indeed, in many instances, symptoms referable to the motor roots, as such, are often entirely absent throughout the disease.

Sensory Nerve-root Pressure.—The symptoms of sensory nerve-root pressure are pain, together with paresthesia and hyperesthesia. The pain is neuralgic in character. At first it may be localized in some small area of distribution, and more or less intermittent. It may at first be unilateral. As time goes on, it becomes more severe, constant, and of an agonizing, lancinating, tearing or burning character. The situation of the pain is often a valuable aid in the diagnosis. After it has existed for some time it spreads and involves new areas. It does not correspond in situation to the course of the peripheral nerves, but involves an area which corresponds to the sensory area supplied by one or more sensory nerve roots. These areas will, of course, depend for their situation upon the portion of the spine involved. This pain differs from pain of ordinary neuralgia, from the fact that it grows worse under any form of treatment and that tender points are absent along the course of the sensory nerves, and, further, that *it is sooner or later bilateral.* Thus, double sciatica is highly suggestive of an intraspinal tumor. When one or more nerve roots are destroyed there will be diminished tactile sensibility and later anesthesia, but paresthesia and pain persist. This is true even when the spinal cord itself is involved (anesthesia dolorosa). In addition to the pain there is often spasmodic contraction of the muscles. As the tumor grows, new nerve roots are involved and new painful areas develop in consequence. The pain and hyperesthesia are terribly severe. They are increased by the slightest motion, so that these patients try to hold themselves as quietly as possible. Coughing and sneezing render the pain much worse. In the painful areas, *herpes zoster* not infrequently develops. Owing to the fact that the tumors occur on the posterior surface of the cord, muscular cramps and twitching may long be absent or not appear at all.

Cord Symptoms.—The period during which the symptoms are entirely referable to the nerve roots varies much in different cases, according to the character and rapidity of growth of the tumor. Cord symptoms may be absent for months, or even, in certain cases, for years. The symptoms, when they appear, vary according to the portion of the cord involved. They consist of motor and sensory paralysis and in changes in the reflexes, and are due to compression or destruction of the cord. They are commonly divided into *direct* and *indirect* symptoms. The *direct* symptoms are those due to compression or destruction of the cord, and may be the immediate cause of death, as, for example, if the tumor be situated in the cervical region, paralysis of the phrenic nerve may produce a fatal result. The motor paralysis usually develops first in the feet

and advances slowly or rapidly upward. The sensory paralyses are usually delayed and only reach the same grade as the motor paralyses late in the disease in many cases. The paralyzed muscles undergo atrophy, with the reaction of degeneration in the muscles whose centers are destroyed. The tendon reflexes in the groups of paralyzed muscles are lost. The sensory symptoms consist of anesthesia, which may be accompanied by loss of pain and temperature sense, or these may exist without anesthesia. The *indirect* spinal symptoms from pressure upon considerable areas of the cord consist of paralysis of the bladder and rectum, with exaggeration of the motor reflexes. The paralysis may be bilateral from the start, or in other cases only half of the cord will be involved at first, and the paralysis may remain for a time unilateral. Since the tumor frequently first involves one side of the cord, there may be Brown-Séquard paralysis, and the anesthesia naturally first involves that side of the body opposite to the tumor. The various forms of sensibility may be disturbed in a variety of ways. The disturbance usually begins in the feet and extends gradually upward. The loss of sensation is usually partial at first, and all forms of sensibility may be diminished, or in other cases, while all forms are diminished, they are not diminished to the same extent. A painful girdle sensation is often present near the level of the tumor; as was true in the case of myeloma occurring in the New York Hospital, which had compressed the cord. Such a painful area may be hyperesthetic. If the tumor is in the cervical region anywhere above the first dorsal segment, there may result paralysis of the sympathetic in the neck, with narrowing of the palpebral fissure and sweating of one side of the face. It is to be borne in mind that, while *spastic paralysis* is produced by tumors in the *upper portions* of the spinal canal, such is not the case in tumors of the *lumbar region*. Tumors here situated cause atrophic flaccid paralysis, with absence of reflexes. Tumors of the cauda equina also produce flaccid paralysis of the legs, paralysis of the bladder and rectum, and widespread neuralgic pain in the lower extremities. As already stated, symptoms referable to the spine itself, such as rigidity, localized tenderness and pain, may be present or absent. If they are present, they may give a valuable hint as to the situation of the tumor. In tumors of the conus medullaris the symptoms often develop quite rapidly, pain is less marked in these than in tumors of the cord above, or the cauda below, anesthesia may early develop, or there may be dissociated sensory disturbances, tactile sensation being preserved.

Prognosis.—The prognosis of intraspinal tumors, if we except syphilis and tuberculosis, which may improve or get well under suitable treatment in time, is absolutely bad, unless the tumors are so situated and of such a character that they can be removed by surgical operation. Death occurs, sooner or later, in every case, after a period which appears to be quite variable. Starr gives the average duration of life as sixteen months, but life has sometimes been prolonged for a number of years. The higher the position of the tumor in the spinal canal the worse the prognosis.

Diagnosis.—The diagnosis of the presence of a spinal tumor can usually be made fairly early and with a fair degree of certainty. Among the important questions to be answered in the diagnosis are

1. Is a spinal tumor present?
2. Is the tumor solitary or multiple?
3. What is the situation of the tumor?
4. What is its character?

1. It is difficult to make the diagnosis of the presence of an intraspinal tumor in some cases; easy in others. Suggestive of an intraspinal growth is intense and persistent neuralgic pain, limited in its distribution to the areas supplied by one or more root zones. As stated, under spinal tumors, the tender areas along the course of peripheral nerves are absent. A bilateral distribution favors the existence of an intraspinal growth. Absence of tender points over the vertebræ and increase in the intensity of the pain on motion are suggestive of an intraspinal growth. Tuberculosis of the vertebræ is characterized in general by a more rapid course than we see in spinal tumors. The nervous disturbances are usually bilateral from the start. There is often fever in the evening, the urine in many cases contains *peptone*, the patients are usually children or young adults. The development of kyphosis of the character almost peculiar to tuberculous disease will usually suffice to exclude an intraspinal growth. In tuberculosis the occurrence of abscess is common; and if under appropriate treatment improvement occurs, we may be quite sure that a spinal tumor does not exist.

2. If the tumor is solitary, the neuralgic symptoms will at first be limited to a circumscribed area. If several regions are involved by different tumors, or if the process is diffuse and not circumscribed, several areas will be the seat of pain, and these may point to widely different localizations in separate nerve roots.

3. Extradural, intraspinal tumors are more often malignant than benign. They tend to extend up and down the dura quite rapidly and thus progressively to involve more and more sensory nerve roots before they cause pressure symptoms upon the cord. Such root symptoms may, as already stated, last for a long time, without the addition of cord symptoms. The extradural growths are also more apt to involve the bone and produce symptoms referable to the spinal column than are intradural or intramedullary growths. Because the former are more commonly malignant, the whole course of the disease is apt to be more rapid and to cause death at an earlier period. Thus, notably, if the tumor within the spinal canal is metastatic, there may be tumors in other situations, or the patient may soon exhibit the signs of a cancerous cachexia. In many of these cases the X-rays may do much to clear up the diagnosis, as is also the case in tumors of the vertebræ. In every doubtful case they should be used at the earliest possible moment. In extradural tumors the root symptoms are more apt to be bilateral, or soon to become so, than is the case with intramedullary growths. Still, with all these aids in

diagnosis, it is often impossible to say whether a tumor is extradural or intradural.

4. It is rarely possible to infer with certainty before operation the character of an intraspinal growth. If there are tumors situated elsewhere in the body, this circumstance will, of course, render it extremely probable that the spinal tumor is of the same character. If the progress of the disease is extremely slow, the probabilities are that the tumor is benign. If spina bifida coexists, the tumor is probably a lipoma. A distinct history of syphilis renders the presence of a gumma extremely probable. In all cases we should carefully question the patient as to a previous history of any surgical operation in the past for the removal of a growth, or, if he is ignorant of the character of a preceding operation, we should spare no pains to inform ourselves of the facts. The diagnosis of intraspinal tumor having been arrived at, the probability is in favor of sarcoma rather than anything else, since this type of growth is more common than any other. The accurate diagnosis of intramedullary tumors is the most difficult to make. In these, root symptoms may appear late or not at all, and the early symptoms are more apt to be of a character pointing to a lesion of the spinal cord itself. Dissociated paralysis of sensation is common in intramedullary growths. The localization of tumors of the spinal cord must be made from a knowledge of the distribution of the several spinal segments and of the nerve roots. The details have already been given under injuries of the spine. In a general way the surgeon will always do better by calling in a skilled neurologist to aid him in the diagnosis, since few surgeons possess the necessary knowledge and special skill requisite to properly examine and interpret the signs and symptoms in these cases.

CHAPTER IV

CONGENITAL ANOMALIES OF THE SPINE

HYDRORRHACHIS (SPINA BIFIDA)

During embryonic development there forms upon the dorsum of the embryo a groove in the ectoderm, the medullary groove, which gradually becomes more marked until it forms a deep sulcus. The epiblastic walls of this groove gradually arch across and finally become united posteriorly in such a manner that the groove is converted into a canal, forming the epiblastic lining of the central canal of the spinal cord below, and the lining of the ventricles of the brain above. The nervous structures themselves, the membranes surrounding the cord, the spinal vertebræ, and the muscles of the back and connective tissues, are developed from the mesodermic layers of the embryo. In certain cases the epiblastic layers from either side fail to unite completely upon the dorsal aspect of the medullary groove. The spinal canal and its membranes thus remain open posteriorly. The spinal canal then forms a mere gutter. The condition is known as *rachischisis.*

In some cases the failure of these layers to unite may involve the entire length of the spinal canal, in which case the condition is known as total rachischisis, or it may involve an area corresponding to the position of two or three vertebræ, in which case it is known as partial rachischisis. The closure of the medullary groove begins in the upper dorsal region and advances in both directions. The lowermost portion of the canal closes last, and in this region there occur most often the partial failures of union. In these cases, characterized by v. Recklinghausen by the title of open myelomeningoceles, there is, of course, an absence of skin over the seat of the defect. The structures contained in the spinal canal bulge posteriorly into this space. In the median line lies the imperfectly developed spinal cord appearing like a smooth red band upon the surface of the pia, the latter recognizable by its vascular, glistening, or velvety surface. At the upper and lower border of the cleft a dimple may sometimes be recognized indicating the position of the central canal of the spinal cord. This area where the pia lies exposed is known as the *zona medullovasculosa.* Upon either side of this surface the pia is covered by epidermis, giving it the appearance of a recent scar. This area is known as the *zona epithelioserosa.* Outside of this the dura and pia gradually merge into the surrounding normal skin. The imperfectly developed structures here described may bulge prominently above the level of the back, constituting a tumor of some size.

In these cases of open myelomeningocele infants do not long survive. Purulent infection of the surface of the pia takes place, death occurring from meningitis and sepsis. The cord is in most cases imperfectly developed and the children are often born with total or partial paralysis of the lower extremities, together with paralysis of the bladder and rectum. In another group of cases the epiblastic layers from either side unite upon the dorsal aspect of the medullary growth, thus separating the integument of the back on the one hand from the lining membrane of the spinal canal on the other, but the fusion stops at this point. Normally, after the fusion has proceeded as far as this, the mesoblastic structures—namely, the laminæ of the vertebræ, the muscles, and the other structures which go to make up the wall of the back—approach one another from either side, meeting in the median line and forcing their way between the epiblastic layers which constitute the skin of the back posteriorly and the lining of the spinal canal in front. In certain cases this complete fusion does not take place, and in these the medullary grove is occupied posteriorly merely by the epithelial covering of the integument behind and the epithelial lining of the spinal canal in front. Thus, the spinal canal comes to be closed merely by a thin membrane formed of the two epiblastic layers.

The above is the most rational explanation of the congenital deformities of the back commonly grouped under the general title of *spina bifida*. From the above it can thus be readily understood that if the spinal canal remains completely open, no union whatever occurring between the epidermic walls of the groove, there is always in addition a failure to unite of the integument of the back, and also a defect in the bony walls of the spinal canal. In very rare cases, possessing no surgical interest, the cleft lies ventrad to the spinal canal. If, on the other hand, a central canal is formed with complete closure posteriorly, then the integumentary covering of the back is also complete. In the latter group, nevertheless, there may be arrest or failure of development of the various mesoblastic structures which go to form the coverings of the spinal cord behind. If the union of the dura is incomplete, there is usually also a defect in the laminæ of the vertebræ. The various degrees of defects commonly grouped under the general head of spina bifida are three, though sometimes two types of defect may exist in the same individual. They are (1) spinal meningocele, (2) myelomeningocele, (3) myelocystocele, also known as syringomyelocele. A combination of the third group, together with meningocele, also occurs. It is known as myelocystomeningocele. In all these groups there is present a defect in the bony canal. Generally speaking, they all have this in common, that the child is born with a tumor, usually in the lower part of the back in the median line. The tumor is more or less rounded or globular in shape, contains fluid, spinal membranes or nervous structures, and communicates with the interior of the spinal canal.

Meningocele.—It is possible that a meningocele may make its way between the arches of normal vertebræ. Such an occurrence is, however, very rare. In most of the cases of pure meningocele the cleft in the vertebræ is narrow, there is

a hernial protrusion of the arachnoid, which becomes distended with fluid and forms a single globular cavity covered by normal skin. The cleft in the bone is narrow, and if the tumor formed in the back is of considerable size and under some tension, it may not be possible to detect the defect in the posterior wall of the vertebral column by palpation. In some cases, however, it will be possible to make out that the neck of the sac is constricted and narrow. The cleft in the bone, if distinguishable, will be found to one side of the median line.

FIG. 32.—SPINA BIFIDA, MENINGOCELE. Operative recovery. (Case of Dr. Wm. A. Downes.)

FIG. 33.—SPINAL MENINGOCELE. (Drawing by Dr. B. S. Barringer.)

Myelomeningocele.—Some of the characters of myelomeningocele have already been mentioned. The cleft in the vertebræ is always much wider than in the preceding form and usually involves a failure of union in three, four, or more vertebræ. The sac is much broader at the base and may be subdivided into several loculi. The herniated structures belonging in the spinal canal, the cord, or the nerve roots, sometimes the cauda equina, are often spread out upon the dorsal surface of the sac and may frequently be distinguished through their thin covering. A dimple over the summit of the swelling is often observed at the point of attachment of the spinal cord. The nerve roots traverse the wall of the sac in loops on their way to reach the intervertebral foramina. The general shape of the sac is broader and flatter than is the case with meningoceles. Upon the summit of the swelling a superficial ulcerated surface is commonly observed.

Myelocystocele.—In myelocystocele, associated with the cleft in the vertebræ and the imperfect fusion of the structures of the back in the median line,

there is a dilatation of the central canal of the cord by serous fluid. As the result of pressure the structures of the cord undergo atrophy. The skin covering of these tumors is usually thinned out and often becomes adherent to the underlying arachnoid, either as the result of infection, or from adhesions and changes in nutrition produced by pressure. The sac observed posteriorly contains few nervous elements, since it consists of the distended central canal of the cord. The dura does not enter into the formation of the sac in these cases. The cleft in the bones in myelocystocele is often quite narrow and is frequently situated on one side of the median line. Children born with this defect often exhibit other congenital deformities, such as club-feet, curvatures of the bones of the extremities, an abnormally short or bent spinal column, partial or complete failure of fusion of the structures normally uniting ventrad to the spinal column, the bladder, the intestine, etc. As the result of pressure, inflammation and ulceration of the surface of the sac commonly occurs, and such a sac may even burst externally. Usually the nervous mechanism of the cord is seriously

FIG. 34.—SPINAL MENINGOCELE. (Case of Dr. Hitzrot.)

interfered with, though in rare cases it may be fairly well preserved. Myelocystocele may be combined with meningocele and the myelocystocele may lie wholly or partly dorsad or ventrad to the meningocele. Whichever position the cord takes, with reference to the meningocele, atrophy of the cord with extensive paralyses of the extremities and usually of the bladder and rectum are commonly present. The structures of the cord are usually forced out of the cleft in the spinal column and lie upon the dorsal surface of the meningocele, or a portion of the cord may lie ventrad and another portion dorsad to the meningocele.

Spina Bifida Occulta.—Spina bifida may occur in any region of the back, but it is most common in the lumbar and sacral regions. In certain forms, although a defect exists in the bones, there is no protrusion of the cord or its membranes. The condition is known as *spina bifida occulta.* A common character of this, together with the other forms in case the individual survives, is the growth upon the surface of the skin overlying the defect of an unusual quantity of hair. Not infrequently, also, the skin may exhibit evidences of cicatricial contraction. The presence of an overgrowth of hair in this region is always suggestive of spina bifida. I saw a woman in the New York Hospital who had a growth of hair over the lumbar and sacral regions covering an area as large as the palm of a man's hand. The hair was thick, long and black. While no external tumor existed, there was a slight congenital defect of the spinal vertebræ in this region. The patient added to her income by exhibiting this peculiar growth of hair.

Spina bifida occurs rarely in the cervical and dorsal regions. Spinal meningocele occurs more often in the sacral region than in any other.

Symptoms.—While many cases of meningocele produce no definite symptoms other than the presence of a tumor having the characters already mentioned, in some there exists also weakness or paralysis of the muscles of the lower extremities and interference with the functions of the bladder and rectum. Still, these latter symptoms are more commonly observed in myelocystocele, associated, as already stated, with other congenital deformities. The cases in which no fusion has occurred and where the central canal of the spinal cord remains wholly or partly open are in general of no surgical interest. They may, as a rule, be recognized at a glance. Such children are almost never viable. In other cases, the presence of a tumor in the median line of the back of an infant is always suggestive of the presence of spina bifida. Some of these cases closely resemble a mere lipoma in this situation, but the surgeon should always be cautious in making such a diagnosis when the tumor exists in the median line and in the lower portion of the back.

In some cases the cleft in the bones can be felt; in others, on account of the size or position of the tumor and the narrowness of the cleft, it cannot. If the child, when first seen, is of such an age that the ossification of the vertebræ is fairly well advanced, an X-ray picture will greatly aid in the diagnosis by showing a failure of development of certain vertebræ, and sometimes in addition the presence of abnormally placed bony elements. (See Sacrococcygeal Tumors.) If, on the other hand, the bones are still largely cartilaginous, the X-ray will not aid in the diagnosis. The congenital character and position of the tumor will always be suggestive. If, as usual, the tumor contains fluid, coughing, straining, and other movements which increase the tension within the cerebro-spinal canal will be followed by an increase in size or in the tension of the tumor. In all the varieties the contained fluid is cerebro-spinal fluid.

The differentiation between the several forms of spina bifida is, however, in many instances extremely difficult. As stated, the complete clefts where

no fusion has taken place are very easily recognized, and the same is true of some of the myelomeningoceles in which the skin is wanting over the central portion of the sac. In the myelomeningoceles, pressure upon the tumor may render the child unconscious, or partly so. In these cases, also, such pressure will cause an increase of tension at the fontanels of the skull, and such increase of tension will be more marked in this group than is the case with meningoceles. In the former, also, paralyses of the extremities and of the bladder and rectum are much more commonly observed. In some of the myelomeningoceles, if the sac be illuminated by transmitted light, it will sometimes be possible to see nerve roots passing through, or adherent to, the wall of the sac.

FIG. 35.—SPINA BIFIDA, MENINGOCELE. (Case of Dr. C. L. Gibson.)

The meningoceles may be said to be usually situated in the sacral region. The opening in the spinal vertebræ is usually small. Paralyses are relatively infrequent. The neck of the sac is usually narrow. In myelomeningoceles the tumor usually has a broad base, skin is absent over the center of the sac, or, if present, it is frequently ulcerated, or the seat of scars. Meningoceles are apt to be of a globular and symmetrical shape. The myelomeningoceles are usually more sessile, less prominent, flatter, and may be umbilicated at the site of the attachment of the cord. Paralyses and associated deformities are common.

Prognosis.—The prognosis of spina bifida is generally gloomy. In the more complicated cases, as already described, the children are rarely viable and they usually die during the first few weeks or months of life. In the complete clefts, where no fusion has occurred and where the pia is exposed to infection, death from meningitis usually occurs early. Ulceration and rupture of the sac in the cases of myelocystocele are commonly followed by early death, although a very few spontaneous cures have been reported. Very few of the

cases other than mere meningoceles are alive at the end of five years. The meningoceles are the most favorable group for operative cure, yet even in these cases the prognosis is not very hopeful. Many of these children, even if operated upon successfully, subsequently die of hydrocephalus, or of some intercurrent disease.

Recapitulation of the Differential Diagnosis of the Several Forms of Spina Bifida.—Spina bifida in some of its varieties occurs about once in a thousand births. In the differential diagnosis the position of the tumor is of some consequence. Meningoceles occur almost always in the sacral region. The other forms, while they more commonly occur in the lower portion of the spine, may have their site in any region of the back. Meningocele is often a globular and more or less pedunculated tumor. The pedicle in myelocystocele is often narrow. If the two conditions are, however, combined, the cleft in the vertebræ is apt to be very much larger. In this latter composite group the spinal cord is apt to be displaced backward, its elements lie in the sac and are grouped on either side of the median line. In the meningocele and myelocystocele, if the case is seen soon after birth, the skin overlying the tumor may have a normal appearance; later it is usually changed by pressure, often by ulceration. This ulceration may be so extensive that it may not be easy to distinguish between these conditions and the cases of complete want of union—i. e., rachischisis and myelomeningocele. The cases of *spina bifida occulta*, in which no tumor is present, may be hard to recognize with certainty, unless a good X-ray picture can be taken. In the last group, an abnormal growth of hair over the lower part of the back is suggestive and the condition is sometimes associated with other deformities of the spine and of the extremities. At or about the age of puberty, paralytic symptoms are not infrequently developed in *spina bifida occulta*. (See below.) In many instances of spina bifida, however, we shall be unable to distinguish one form from the other until the sac is exposed and opened by the knife at the time when operative cure is attempted. The operative methods in all cases closely resemble those done for the radical cure of hernia. The procedures consist of a careful exposure and isolation of the sac, opening of the sac, separation and replacement in the spinal canal of nervous structures, excision of the sac and suture of its neck, closure of the external wound, and the most painstaking efforts throughout to secure primary union.

Spina Bifida Occulta.—The paralytic symptoms in *spina bifida occulta* do not usually appear until near the age of puberty, or soon after—that is to say, during the years when the body exhibits the most active growth. The explanation of the late appearance of paralytic symptoms is, that there is developed a firm fibrous band, connecting the skin over the cleft with the cord, representing an imperfect separation of the two structures, during fetal life. This band does not grow at a rate corresponding with the growth of the body in general, and, therefore, may make traction upon and stretch the cord, or, in other cases, may compress the cord against the margin of the opening in

the spinal canal. In addition to the development of an abnormal growth of hair over the site of the defect, cicatricial defects in the skin are common in these cases. Spina bifida occulta is not infrequently accompanied by the development of tumors within the spinal canal, or in the cleft between the bones, or outside the spine. Such tumors are of fetal origin. They have been observed in considerable variety. Lipoma, fibroma, myoma, angioma have been described, as well as dermoid cysts and teratomata. When these tumors develop outside the bony cleft in the spine they present as more or less prominent growths on the back. When they develop within the canal, they may in time produce symptoms of pressure upon the cord, paralyses, etc., as already described. The treatment in these cases is the removal of the tumor.

CONGENITAL TUMORS OF THE SACROCOCCYGEAL REGION

A protrusion of the dura between the sacrum and coccyx may occur without any bony deformity, forming a meningocele. In these cases the cavity of the spinal membranes containing fluid extends to an unusually low point. A cystic tumor may thus be formed beneath the skin over the junction of the sacrum and coccyx. It will contain cerebro-spinal fluid. In some of these cases the meningocele is covered by a congenital lipoma, a teratoma, a lymphangioma, or a combination of lipoma with lymphangioma. The nature of teratomata has been sufficiently discussed under tumors. They are supposed to arise from a misplaced fetal nucleus and are not very rare in connection with congenital clefts in the spinal vertebræ.

The congenital lipomata in this region differ from ordinary lipomata in that they are diffuse, not encapsulated tumors. As already stated, in the presence of a congenital lipoma in the lower part of the median line of the back, the surgeon should always be on his guard against undertaking the operative removal of such tumors lightly, since many of them overlie a meningocele.

Dermoid Cysts.—Dermoid cysts may develop in the sacrococcygeal region. Their favorite sites are over the junction of the sacrum and coccyx, or over the tip of the coccyx itself. Such dermoids not infrequently become infected and break through the skin, leaving behind a suppurating tract, which does not heal until the entire dermoid is removed by operation. Much more rarely dermoids may develop in front of the coccyx or sacrum. They have their origin in misplaced portions of that part of the primitive intestine known as the *postanal gut*. Such tumors may contain a variety of fetal structures. In the female they may grow forward and upward, raising the uterus and the broad ligaments without penetrating between the layers of the latter. In this way they may be distinguished from the commoner forms of dermoid cysts developing from the ovary.

The origin of the congenital sacrococcygeal tumors has been considerably discussed, especially the origin of those forms which arise in front of the sacrum and coccyx. It is to be borne in mind that at a very early period of

fetal life the medullary canal is open at its lower end and is continuous with the lower end of the primitive alimentary canal, at a point behind the place where the anus is later to be developed. It may thus be understood that tumors developing at this point may contain not only epiblastic but also hypoblastic structures. Thus, in these tumors, we not infrequently find rudimentary structures resembling parts of many different organs. While this explanation serves for a certain proportion of cases, it is believed by many observers that in the more complex forms the tumor is developed from a second ovum, which is partly suppressed and undergoes imperfect development.

Clinically, many of these tumors remain small and produce no symptoms. Sometimes they are recognizable at birth; in other cases not until later years, when they may grow slowly or rapidly, in the latter case taking on a sarcomatous type. In some cases they reach a considerable size and may produce marked discomfort from deformity and from interference with the sitting posture. The dermoids which suppurate, often give their possessors considerable annoyance by forming a persistent fistula in the sacrococcygeal region. They are often mistaken for ordinary abscesses in this situation. I have known of cases operated upon several times by competent surgeons before the true nature of the condition was recognized. In those cases where the tumor occurs in front of the sacrum and coccyx the symptoms produced are those of pressure upon the rectum and upon the uterus in females. The exact diagnosis may sometimes be made by rectal palpation. In other cases, the diagnosis will not be made until the tumor is removed. *Caudal appendages*, or so-called false tails, are occasionally observed. They usually consist merely of fat and fibrous tissue covered by skin. In a few cases they are connected directly with the end of the coccyx and may contain muscle and be mobile. True tails containing additional vertebræ do not occur, as far as we know.

CHAPTER V

INJURIES OF NERVES

Although the injuries of nerves have received brief mention when speaking of the diagnosis of wounds in general, this topic is so important from a practical standpoint that I think it desirable to describe the diagnosis of these injuries somewhat more in detail. The subject is one which usually arouses in the general surgeon less interest than it deserves. Total loss of function in one of the large nerve trunks of an extremity is a very serious accident indeed; it may entail upon the individual not only much physical suffering, but may also impair his usefulness to a great degree. Thus, loss of function in the median or ulnar nerves will, unless the injury can be repaired, render the individual entirely unable to pursue a calling which demands accurate and skillful use of the fingers. The same is true, though to a less extent, of serious injury to the musculo-spiral; and in the lower extremity loss of function in the external popliteal will seriously cripple the foot and leg. The nerves above mentioned are those most commonly injured as the result of accident.

The generally accepted idea in regard to regeneration of divided nerve trunks is, that the peripheral portion of the nerve undergoes complete degeneration, as far as its power of conducting nervous impulses is concerned. For the regeneration of such an injury, the trophic centers of the nerve must be preserved and the regeneration is believed to take place by a growth of new nerve elements centripetally from the end of the proximal portion. In order, however, that such regeneration may occur, it is necessary that the divided ends of the nerve should remain, or be brought by suture, into contact. If the nerve trunk is actually divided as by the cut of a knife, a piece of glass, or other sharp instrument, the nerve ends must be sutured, or regeneration will not take place. If the division is incomplete, as where a nerve trunk is merely contused, partly divided, or lacerated, without total solution of its continuity, regeneration will usually take place, after a period which varies from a few months to a year, or more, without artificial aid. In nerve trunks divided and united by suture regeneration requires a long time, which varies much in different cases and is delayed, or may partly or wholly fail under certain conditions. If the nerve ends are not brought together very soon after the injury, or if infection takes place in the original wound, the time of regeneration will be long. *The greater the distance of the point of division from the peripheral endings of the nerve, the longer the time required.* That is to say, the greater

the length of the new fibers which must be reproduced, the longer the time which must elapse before regeneration is complete. Under the most favorable conditions, regeneration may begin in a few weeks, but the finer appreciation of sensory stimuli cannot be expected to be complete in less than two years. (Sherren.) If a nerve is completely divided and the ends are not brought in contact, the function of the nerve is forever lost. The degeneration of the peripheral portion of a divided nerve may be observed under the microscope after from five to ten days following the injury, and at the end of two weeks the muscles supplied by a motor nerve give the electrical reaction of degeneration.

Causation.—Nerves may be injured by various kinds of violence. As the result of wounds, nerve trunks may be cut, as with a knife or a piece of glass, and the division may be complete or partial. As the result of blunt violence the nerve may be contused, lacerated, or so stretched that its function is abolished. Another large group of nerve injuries are produced by pressure, either momentary or prolonged. The repair in cases where nerves are completely divided is to some extent modified by the general condition of the individual, but this is especially true of contusions of nerves. Depressed vital states, notably chronic alcoholism, renders the return of function slower and in severe cases less complete. The nerve trunks most frequently injured as the result of incised and punctured wounds are the *median and ulnar nerves* near the wrist, and as the result of pressure, the *musculo-spiral nerve* in the middle of the upper arm.

An important group is constituted by injuries of the *brachial plexus* from contusion as the result of injuries in the vicinity of the shoulder-joint, produced by falls, blows, and the like, and also a considerable number produced by violent traction upon the arm. Another group of nerve injuries, often of serious consequence, are produced during surgical operations. The nerves may be accidentally or negligently cut. In operations upon the neck, the spinal accessory nerve is the one most often injured. The resulting paralysis may be quite serious and will be spoken of later. In operations upon the face and upon the mastoid process of the temporal bone, and especially in operations for tumors, or other lesions of the parotid gland, the facial nerve or its branches are often injured. While such injury to the facial nerve is often justifiable, or even necessary, when operating upon malignant tumors of this region, still, in many cases, by exercising due care in the manner of carrying out the dissection, the injury to the facial nerve may be wholly or partly avoided. There is in general slight excuse for injuring the facial nerve when operating upon the mastoid cells and the middle ear.

In operations performed upon the abdomen, the nerves most commonly injured are those supplying the rectus abdominis muscle. This is especially true when a vertical incision is made through all the structures of the abdominal wall at the outer border of the rectus—namely, in the linea semilunaris. These injuries can usually be avoided by making the incision through the anterior layer of the sheath of the rectus and by pushing the muscle toward the median line. If the incision must go through the muscular belly, its fibers should be sep-

arated by blunt dissection, with the fingers, or a blunt instrument. The nerves will then be visible in the wound and may be drawn out of the way by retractors and thus usually preserved. The formation of ventral herniæ following incisions in the abdominal wall to one side of the median line are frequently favored, or even caused, by the division of nerves supplying the rectus, and even if no hernia occurs, that side of the belly remains over a great or less extent prominent, weak, and flabby. In operations for inguinal hernia, the ilio-inguinal nerve is usually distinguishable and should be preserved. If it is cut, the patient may suffer a good deal of pain after the operation.

The nerve most often injured as the result of pressure is the musculo-spiral nerve in the middle of the arm. Such pressure may be transient, as when an individual goes to sleep lying upon the arm, or when, being drunk, he falls asleep with the arm hanging over the back of a chair, producing the so-called "Saturday night" paralysis; or it may be of longer duration, as the result of pressure from displaced bony fragments, in fractures of the shaft of the humerus, or from inclusion of the nerve in the fibrous tissue, or callus formed around the seat of fracture.

As the result of pressure or of traction, the brachial plexus may be injured during general anesthesia. When a patient's arm is permitted to hang over the edge of the table during an operation, pressure upon the musculo-spiral nerve may cause a paralysis which may endure for a number of months. If the arms are placed above the head and allowed to hang, or are fastened in this position, both traction and pressure are brought to bear upon the cords of the brachial plexus—the first by the weight of the arm, the second by the pressure of the head of the humerus. I have seen cases of this kind where paralysis of groups of muscles of the arm and forearm existed, together with pain, in which the symptoms did not disappear until the end of a year. Pressure upon the ulnar nerve at the elbow by carelessly placed dressings intended to support and elevate the arm and shoulder may cause paralysis in the ulnar distribution. This has been especially observed after the application of Sayre's dressing for fractures of the clavicle, where the point of the elbow had not been properly padded for the protection of the skin and of the ulnar nerve. That form of paralysis of the brachial plexus known as "Erb-Duchenne" paralysis will be spoken of under injuries of special nerves. In the lower extremity the external popliteal nerve is more often injured than any other. The injuries occur not infrequently as the result of fractures of the upper end of the fibula, and may give rise to annoying and even serious paralyses. The nerve may also be injured by the use of Clover's crutch in operations for stricture of the urethra, or other procedure upon the perineum.

Gunshot wounds of the nerves have apparently been observed more frequently since small calibered high-powered rifles have been made use of in warfare. The increased frequency of such injuries has been noted especially during the war between the Boers and the English in South Africa, and in the war between Russia and Japan. The nerve injuries were found to involve

chiefly the musculo-spiral nerve in the upper extremity and the sciatic nerve in the lower extremity. The musculo-spiral nerve was injured usually in cases of gunshot fracture of the humerus. The injuries occurred either at the time the shot was received, by small bone fragments which lacerated the nerve, or later, by pressure due to displacement of the bony fragments, or was due to the involvement of the nerve in callus formation. The injuries of the sciatic nerve in the thigh were usually due to a direct wounding of the nerve by the bullet. The nerve was, as a rule, only partly divided.[1]

Injuries to the brachial plexus as the result of dislocations of the shoulder may be produced by the same violence which caused the dislocation, or may occur as the result of improper methods of reduction, rarely from undue traction, occasionally from the pressure of the heel in the axilla. In other cases the injury to the plexus has been gradually developed in unreduced dislocations from the continued pressure of the head of the bone upon the nerve trunks. Injuries of the brachial plexus are more common in subcoracoid dislocations of the humerus than in other forms. In these the inner cord is the part commonly injured. In the subglenoid variety of dislocation the musculo-spiral nerve is sometimes injured. Occasionally only the circumflex nerve.

Symptoms.—As the result of injury, the conducting power of a nerve may be wholly destroyed. This may occur from complete division of the nerve, or in other cases, while the continuity of the nerve trunk is not completely severed, nevertheless, its power of conducting nervous impulses may be wholly or partly lost. In many instances it will be impossible to say for a long time whether the nerve trunk is actually severed, or whether the continuity of the fibrous structures which form the framework of the nerve are still intact. In the latter group of cases the prognosis without operative treatment is, of course, much better, and yet it is unwise to wait too long for symptoms of improvement to occur in cases of doubt. There is no way of telling, soon after the injury, whether the nerve trunk is completely divided or not. If the paralysis is complete, and if at the end of two weeks it remains so and is accompanied by the electrical reaction of degeneration in the muscles supplied by the nerve, it is better to expose the nerve by an open operation in order that suitable union of the ends may be secured, in case the continuity of the nerve trunk is actually severed. In a good many cases the signs and symtoms of injury to a nerve trunk are either incomplete from the first, or improvement soon begins to take place. In these partial injuries the prognosis is, as a rule, quite good for complete ultimate recovery of function. It may be delayed for many months.

The symptoms produced by injuries of nerves are of three kinds. They are, paralysis of the muscles supplied by the nerve, disturbances of sensibility, and trophic disturbances.

Motor Symptoms.—The motor symptoms are usually regarded as most

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[1] James Sherren, "Injuries of Nerves and their Treatment," William Wood & Company, 1908, p. 13.

important. If a nerve is completely divided, the paralysis of the muscles supplied by that nerve occurs at once, and if the muscle or group of muscles receive no other motor supply, the muscle or muscles undergo atrophy. It is sometimes possible to recognize at once from the position of the limb, or from evident inability to perform certain acts on account of muscular weakness, that

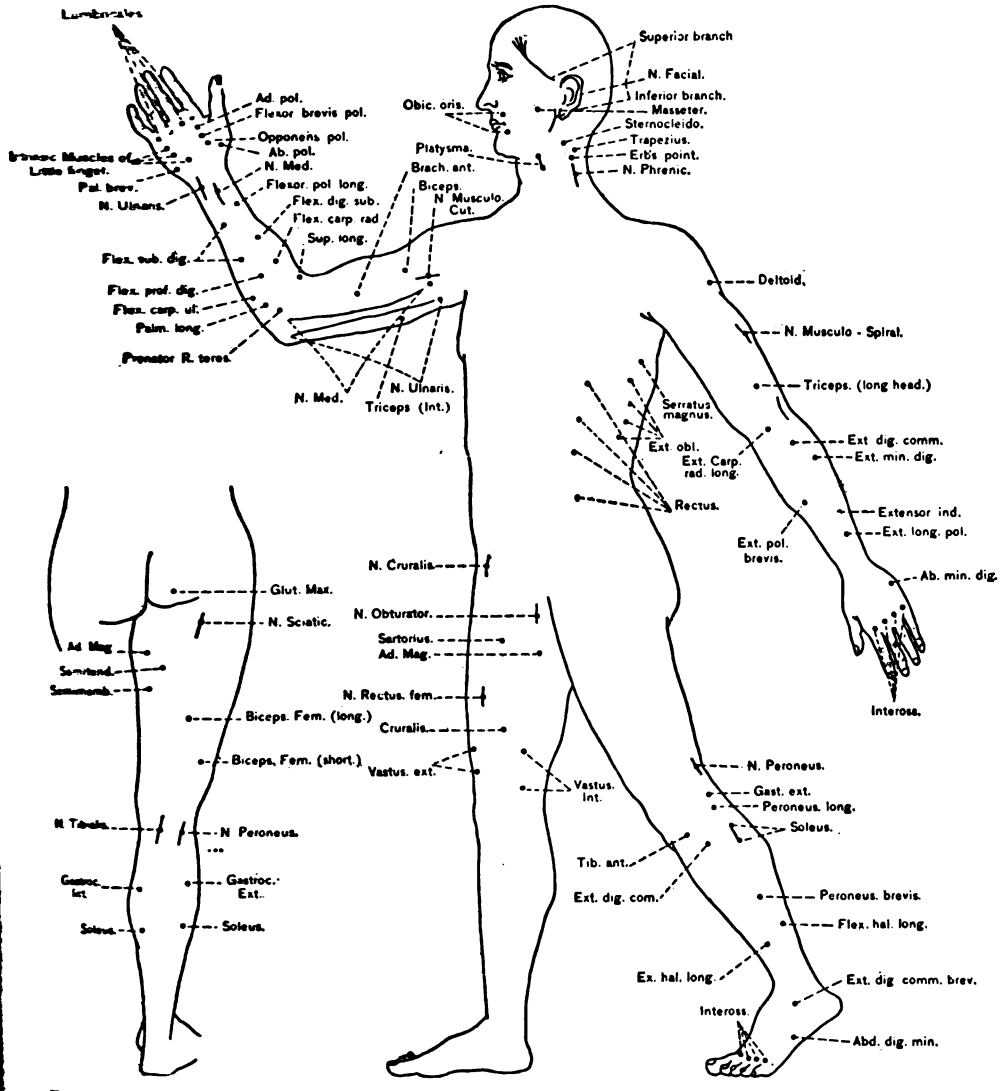

FIG. 36.—DIAGRAM SHOWING THE SUPERFICIAL POSITION OF THE LARGE NERVE TRUNKS AND THE MOTOR POINTS FOR THE MUSCLES. (After Bailey.)

one or other nerve trunk has been divided, or at least deprived of its function. Such paralysis is, however, not always easy to recognize by ordinary means of examination, since nearly all purposive movements are produced not by the contraction of any one muscle, but by groups of muscles; so that in many cases

we are obliged to seek for the evidences of motor paralysis in another way. The most important means of detecting paralysis in individual muscles is by testing their electrical reactions. Therefore, for an accurate diagnosis of nerve injuries, the electrical examination is very important. In order to test an individual muscle, it is necessary to know the point where the motor nerve of the muscle enters it. These points were first worked out by Erb. They are known as motor points. Their situation for the individual muscles may be studied from the accompanying diagram. (See Fig. 36.) Muscles whose motor nerves have been divided exhibit certain changes in their electrical reactions, and after a time exhibit what is known as the reaction of degeneration.

A healthy muscle whose motor nerve is intact and connected with its center in the spinal cord, contracts readily when the Faradic or interrupted current is passed through its motor point and the contraction lasts as long as the current is passing. When stimulated by the Galvanic, or continuous current, a sudden contraction occurs when the current is closed, but does not continue during the passage of the current. The contraction produced by the continuous current is most active and occurs with the smallest quantity of current when the ***kathode*** is applied to its motor point and the *anode* is applied to some indifferent portion of the body. The normal reaction of a muscle to the constant current upon closing the circuit is commonly expressed by the formula K.C.C. > A.C.C. When the motor nerve of a muscle is destroyed, certain changes are observed in its behavior when stimulated by the interrupted and the constant currents respectively. The motor nerve of a muscle having been divided, the reaction to the Faradic current applied over its motor point may be exaggerated for a day or two following the injury, but it soon begins to fall, and at the end of about two weeks no contraction of the muscle occurs when stimulated by this current. The behavior of a muscle whose motor nerve is cut when stimulated by the constant current is different. Immediately after the injury the muscle may respond with increased activity to the constant current. The response then diminishes for a few days, but increases again during the second or third week. This increase may last for some time. It then gradually diminishes and finally, when the muscle fibers are totally degenerated, the contraction may be totally and permanently absent. Such total loss is, however, postponed for a long time and total degeneration of the muscle fibers cut off from their nerves may not occur for a number of years. During this time, however, the muscle undergoes a greater or less degree of atrophy; but soon after the injury—namely, at the end of about a fortnight—the electrical reactions to the constant current change in character. The change consists, in the first place, of a reversal of the normal reaction to the constant current; that is to say, instead of the contraction being, as under normal conditions, K.C.C. > A.C.C., the reverse is the case, and A.C.C. > K.C.C. There is also a change in the form of the response. The muscle contracts more slowly, less vigorously, and in a wavy or wormlike manner. The presence of this reaction, known as the reaction of degeneration, is indicative of a serious injury to the nerve. It is to be borne

in mind that when testing the electrical reactions of muscles, notably in cases of nerve injury, the response to the several kinds and strengths of current should be compared upon the two sides of the body.

The sources of electricity may be an ordinary Galvanic and Faradic battery. The electrodes should be thoroughly soaked in a watery solution of common salt. The electrode which is to be placed upon an indifferent part of the body may well be a large pad electrode, or in some instances it is convenient to place one hand or one food on the patient in a vessel of salted water into which the indifferent electrode is immersed. The electrode used for testing the muscles should be small and its extremity may be covered with a piece of soft leather or chamois skin. The making and breaking of the current is accomplished by a small lever on the handle of the testing electrode, which can be readily depressed by the thumb. It is desirable to have a milliampèremeter in the circuit so that the amount of current necessary to produce a contraction may be observed. There should also be a switch so arranged that the current may be made to pass in either direction at will, thus changing the polarity of the electrodes. In simple cases an ordinary Faradic battery may be all that is required for a diagnosis. In more complicated and difficult cases the constant current must be used. In these, some practice and skill are necessary to enable the examiner to draw accurate conclusions. It is not always easy, during the days following the injury of a nerve, to know whether the nerve is actually divided and its conducting power totally destroyed, or whether, on the other hand, the injury is only partial. Indeed, in many instances, in order to determine this at an early date, it will be necessary to expose the nerve at the point of injury. Bailey states that if, after two weeks, the Faradic irritability of the nerve is completely lost, the duration of the paralysis will be long, and says, further, that in severe injuries, which do not, however, completely sever the nerve trunk, there may be no response to the Faradic current for a number of months and no response to the Galvanic current applied to the nerve, or of the Faradic current applied to the muscle. The Galvanic reactions in these cases may be increased or reversed. If, after several months, these changes persist and the paralysis is not improved, recovery, if it occurs at all, will be very slow. In the cases where the nerve is not completely divided and regeneration occurs, there is usually a return of motor power before any improvement is observed in the electrical reactions. If the nerve is incompletely divided, or its function is only partly destroyed by pressure, or by traction, there is apt to be more pain than is the case after complete division of the nerve. In these cases also trophic disturbances—namely, the appearance known as "glossy skin," to be hereafter described—may be prominent.

Sensory Symptoms.—The disturbances of sensibility following the division of mixed peripheral nerves have been carefully investigated during the last few years by Head and Sherren in England, and the results of their observations have done much to clear up the somewhat complicated disturbances of sensation following the division of nerve trunks. They have called attention

to the results of their clinical observations which lead them to believe that the sensory nerve supply of a part may be divided into three groups of nerve filaments. First, nerve filaments accompanying the motor nerves of muscles and tendons, supplying as well the structures of joints. These nerves anastomose freely and supply what these observers designate as *deep sensibility*. That is to say, while these nerves remain intact, the patient is still able to appreciate pressure upon the part, and if such pressure is severe, painful sensations will be felt, described frequently as sensations such as might be produced by bruising the bone. This group of nerves also permits the patient to recognize the position in which the limb or the joint is placed. If the *muscles* and *tendons* going to the part are also divided, then this form of sensibility will be lost, and the same is true if the nerves supplying the part have been divided above any motor branches. From this it follows that preservation of the sense of deep pressure is compatible with complete division of the sensory nerves supplying the *integument* of the part. That is to say, over the anatomical area supplied by a given sensory nerve of the skin, the patient may still be able to appreciate deep pressure as with a lead pencil or the finger, and the same is true of the prick of a pin. The patient will recognize that the part has been touched, but will perceive no painful sensation, nor will he be able to distinguish between extremes of heat and cold. The second group of nerves provide the integument with sensibility. They correspond closely with the areas of nerve supply ordinarily given for the separate nerves in anatomical textbooks. This sensibility has been designated by Head and Sherren "*epicritic*" sensibility. It is the kind of sensibility which permits the recognition of light touch, as with a pledget of cotton wool lightly passed across the surface, and also the sensibility which permits a distinction between minor degrees of difference in temperature. These nerves also supply that form of sensibility which permits a distinction between a touch by one or by two points on the skin, separated by a small interval. When this form of nerve supply is lost, the points of a pair of compasses must be separated many times more widely than under normal conditions before the individual is able to distinguish between a touch with one or two points. For the sake of brevity this test is usually known as "the compass test." In total division of nerves this form of sensibility takes longer to regenerate than the others, and the duration of such regeneration is said by Head and Sherren to be at least two years.

The third form of sensibility was characterized by Head and Sherren as "*protopathic*" sensibility. These nerves furnish fibers which permit the individual to distinguish the sense of pain, as from the prick of a needle, and further permit the distinction between extremes of temperature, as between ice water and a temperature of 50° C. Protopathic sensibility corresponds in area to epicritic sensibility, but overlaps it considerably.

To make the distinction clearer, assume that a sensory nerve supplying the integument of the hand is divided in the forearm. There will result an area of anesthesia in the hand having definite boundaries corresponding closely to

the distribution of such a nerve given in anatomical text-books. Throughout all this area the *sensibility to light touch will be lost.* If a pledget of cotton is passed lightly across the skin over this area the patient will not perceive its touch, nor will he be able within this entire area to distinguish between *slight* differences of temperature. Ordinary tactile sensibility as commonly known, such as the pressure of a lead pencil or a touch with the finger, or in fact any mechanical stimulus, which depresses the skin, will still be felt, and the same is true of what is known as deep sensibility. Firm pressure will be felt throughout the entire area supplied by this cutaneous sensory nerve. There will also be an area, usually on the fingers merely, and often quite small, where the patient will not perceive a light touch with cotton, where all power to distinguish degrees of temperature will be lost, and where the prick of a needle will not cause pain, although it will still be appreciated as a sensation of pressure. Between the outer limit of the loss of sensation to light touch and the area where, as just described, deep sensibility is alone preserved, there will exist an intermediate area where the sense of light touch will be lost, where the patient will be able to distinguish between extreme degrees of temperature, but where the ability to distinguish between slight differences of temperature will be lost. Over this area, whose proximal limits correspond with the boundary of the area where the sense of light touch is lost, the patient will be able to feel the prick of a needle as a painful sensation, and will be able to distinguish between extreme degrees of temperature. Deep sensibility is also, of course, retained over this area. If, however, the muscles and tendons going to the part are divided, deep sensibility will be lost.

During the regeneration of nerves *protopathic* sensibility returns much earlier than *epicritic*, the last, even under the most favorable conditions, requiring about two years before it becomes perfect. Sherren calls attention to the fact that the effects of dividing a posterior root on sensibility are different from those which follow the division of a peripheral nerve. The division of a posterior root produces an area of loss of protopathic sensibility larger than the area of epicritic sensibility, while the contrary is true of many of the peripheral sensory nerves, except in those cases where the peripheral nerve corresponds closely in its distribution to a nerve root. In the latter case the loss of sensibility to light touch will correspond closely in area with the loss of sensibility to pain. The median nerve is an example of the first class, the external popliteal nerve of the second.[1] Certain peripheral nerves may be divided without sensory loss. These nerves supply no definite area of skin exclusively, with any form of sensibility. Examples of these are the musculo-spiral nerve in the arm and the radial in the upper part of the forearm.

Trophic Disturbances.—The trophic disturbances which follow the division of peripheral nerves consist of changes in the skin, changes in the nails, in the hair, and in the joints and bones. The *changes in the skin* are as follows:

[1] Sherren, *loc. cit.*, p. 25.

The nutrition of the skin is impaired. It becomes dry and hard over a greater or less area, and if the superficial layers of dry horny epithelium are removed, the skin beneath is pinkish or bluish in color, often thrown into fine wrinkles. If the skin over the affected area be pricked with a needle it bleeds more readily than does normal skin, and the prick mark remains for hours or for a day as a red congested spot. Sweating of the skin is also marked. The typical condition known as "glossy skin" follows incomplete injuries of nerves in which the original wound was infected, so that the nerve is embedded in a mass of scar tissue, or it may follow aseptic or subcutaneous injuries. In these cases, as, for example, after incomplete division of the median and ulnar nerves in the forearm, the skin of the hand undergoes a peculiar partial atrophy; it becomes smooth and shiny and appears almost as though it had been varnished. The affected parts sweat profusely. These patients usually suffer from intense pain and frequently become neurasthenic.

Following the division of nerves, the insensitive parts are, unless very carefully protected, subjected to mechanical and thermic injuries, and such injuries more readily produce blisters or ulcers than in normal parts. Exposure of the part to cold or heat is more likely to be followed by the formation of a blister or an ulcer than is the case with normal skin. The lesions heal readily enough under suitable treatment, but are apt to recur; since the hand, being insensitive, the patient is not conscious of the fact that water or air are too hot or too cold. During regeneration, when the sensibility to pain has returned in the part, blisters sometimes form spontaneously. If the injury to the nerve trunk has been complete and has existed for a long time, the phenomenon of glossy skin is marked. If the lesion affects the fingers they become thin and tapering, the part feels subjectively and objectively cold. The *changes in the growth of the nails* consist in alterations of form and of texture. The nail curves over the end of the finger, it becomes harder, more brittle, and often shows transverse or longitudinal ridges. The rate of growth of the nails may be diminished. Beneath the free border of the nails the epithelium becomes thickly piled up into masses. The nutrition of the *hair* of the affected part suffers. The hairs become brittle, and if many hairs are present their arrangement ceases to be normal; they project, each hair in its own particular direction.

Changes in the Joints.—If injuries involving the important nerve trunks of the extremities are not treated with care and intelligence, the contraction of nonopposed muscles will cause the limb to assume some more or less characteristic position, and if the joints of the limb are not moved from time to time these positions become permanent and the paralyzed muscles shortened. The joints also become stiff, and in neglected cases fibrous ankylosis may occur and be practically incurable.

While the signs and symptoms of injuries of special nerves will be described under proper headings, a few general remarks may not be out of place here. In examining for injuries of nerves in recent open wounds, as of the wrist and forearm, it is well to test the sensibility of the hands and fingers before

seeking to repair the injured tissues. In this way the presence of an injury to the median or ulnar nerve will be recognized, whereas if these tests are not made, the surgeon may forget to inspect the nerves in the wound. When the tendons are divided above the wrist, it is to be remembered that in case the median and ulnar nerves are also cut, the loss of sensibility in the fingers will be absolute. In injuries already healed, or where no wound exists, it will be impossible to tell, except by the electrical reactions of the muscles, whether a nerve is completely divided or not.

The examination for sensibility to heat and cold is tested by means of test tubes filled with water at various temperatures. Thus, tubes containing iced water and water at 50° C. may be used for testing the perception of differences of extremes of temperature. Such extremes can usually be distinguished over the area where sensibility to pain persists (protopathic sensibility), while no differences will be noticed between slighter extremes of heat and cold. By inspecting the position of the limb, or the attitude of the patient, it is often possible to tell at once what nerve is injured. These peculiarities will be mentioned when speaking of the injuries of special nerves.

Prognosis.—Slight injuries of nerves, such as are produced by pressure continued only for a short time, are as a rule, speedily recovered from, yet even in these cases, as, for example, in the so-called "Saturday night" paralysis, the drop wrist may last for several weeks. The prognosis in injuries of the brachial plexus, when the cords are torn or crushed, is exceedingly bad. If the injury is only slight, recovery may be expected in a few weeks, but if there is a pronounced paralysis, with changed electrical reactions, the prognosis is much worse. In the worst cases no recovery takes place. In the less severe it is delayed for a number of months. In the cases where nerve trunks are completely divided the prognosis depends to a great extent upon the time allowed to elapse before the nerve ends are sutured. The sooner it is done the sooner is recovery likely to commence and the more likely is it that complete return of function will ensue. In any case of nerve injury in which the reaction of degeneration develops in the muscles at the end of a fortnight, operative treatment is required. If operation is done very early, nearly all cases will be improved. In what proportion of cases complete return of function will result it is hard to say, the question depending upon so many different conditions. If the wound becomes infected, the chances of complete recovery are much less, and if, during the year following the operation, careful attention be not given to the position of the limb, to keeping up the nutrition of the muscles by massage and electricity and to passive motion of the joints, the end result is not likely to be perfect. In those cases where the suture is done early and where aseptic healing is obtained, and the limb receives proper after treatment, the chances of perfect recovery, as far as sensation goes, is excellent, but in general complete return of sensation is delayed for two years. Motor power in most instances occurs in about a year, though the time of such recovery will vary somewhat according to the length of the distal portion of the nerve, which must

regenerate, the general rule holding that the farther the point of division from the nerve endings in the muscle the longer the process of regeneration will take. As the motor power begins to return, the electrical reactions of the muscles change also. The muscles begin to react more vigorously and more promptly, and after a time the normal K.C.C. > A.C.C. will be observed. If a plexus is divided, or a nerve which supplies a number of muscles, those muscles nearest the trunk—i. e., farthest from the periphery—will regain their power first. The sensory symptoms begin to improve before the motor symptoms. After the sensibility of the skin to slight stimuli has returned, there may be tingling and painful sensations in the affected part. The last sensory function to be regained is that sort of sensibility which permits the individual to distinguish between one or two points of contact upon the skin at the shortest possible distance, and this power usually does not return before the end of two years. In cases of *secondary suture* the return of motor power in the muscles is apt to be, even in the most favorable cases, incomplete, since in these a greater degree of atrophy of the muscle has occurred before regeneration can take place. Some muscles may become permanently shortened and perfect function in these cases is not regained. As long, however, as the muscles may be made to contract when stimulated by the constant current, there is still some hope of a partial return of power, if the divided ends of the nerve are united. In general the longer the time elapsed after the injury before the nerves are sutured, the slower the recovery of function and the less likelihood of perfect recovery. Sherren believes that the time which has elapsed between the injury and the union by suture of the nerve ends is less important in prognosis than is the question of whether the original wound healed in an aseptic manner or suppurated. In the latter case he considers that the period of recovery will be longer and less complete. In favorable cases of primary suture sensory recovery may be expected to begin in from six weeks to four or five months after the nerve ends are reunited.

CHAPTER VI

THE PELVIS

INJURIES OF THE PELVIS

Fractures of the Pelvis

The pelvic girdle is very strong and is only fractured by extreme degrees of violence. The elasticity of the bones is notably increased by the ligamentous union between the sacrum and the ilium, to which are added the lesser and greater sacro-sciatic ligaments behind; and by the ligamentous union at the pubic symphysis in front. The pelvis is, moreover, quite well protected by the overlying soft parts, muscles, fat, etc.

The pelvis may be fractured by several kinds of violence, applied in a variety of ways. For example, falls from a height in which the patient strikes upon the buttocks, or upon the knees or feet. Crushing injuries, of which a classical example is when an individual is caught and crushed between the buffers of railway cars or between a boat and a dock. Blows or falls in which the violence is directed from before backward may cause a fracture of the pubis, or a combination of fracture of the pubis with fracture of the ilium or ischium. In cities, one of the commonest causes of fracture of the pelvis is the passage of the wheel of a heavy vehicle across the body. In other cases the body may be caught between a moving elevator and the floor. Several cases have been recorded in which a running or leaping horse fell upon his rider. A fatal case occurred in the New York Hospital in March, 1909. A man was caught between a ferryboat and the dock. The rami of the pubes and ischia were fractured; his bladder was ruptured; he died of shock. The most dreadful injuries of this kind which I have ever seen have been caused by the passage of the wheel of a trolley car or of a locomotive across the body. In most of the cases of fracture of the pelvis the gravity of the injury depends not upon the injury to the bones, but to the soft parts contained within the pelvis. Of the latter the most frequent injuries are to the urethra and urinary bladder; less often to the blood-vessels (iliac arteries or veins) and nerves (roots of the lumbar and sacral plexuses or the sciatic nerve). To illustrate the frequency of injuries to the bladder and urethra, I may say that among seven cases of fracture of the pelvic ring coming under my observation the bladder was ruptured in five, the membranous urethra in two. Fractures of the pelvis are not very frequent injuries. Bruns estimated that fractures of the pelvis constituted only

0.3 per cent of all fractures. In the statistics of L. A. Stimson, there were 6,904 fractures treated in the Hudson Street Hospital and Dispensary between 1894 and 1899; of these, 29 only were fractures of the pelvis.

Fractures of the pelvis are ordinarily grouped under two main heads—namely, those fractures which break the continuity of the pelvic ring, and fractures which involve the individual bones without breaking the ring. We shall first consider those fractures which cause a rupture of the pelvic bony girdle.

Fractures Causing Rupture of the Pelvic Bony Girdle.—The front part of the pelvic girdle is most often broken, since here the bones are thinner and where also are to be found the lines of union between the separate bones during early life. The results of fracture follow fairly definite directions. If the front part of the pelvic ring is fractured by the force which acts from before backward, the horizontal ramus of the pubis is fractured, sometimes upon one side and sometimes upon both, the line of fracture running down into the obturator foramen, or the fracture may occur at the junction of the pubis with the ilium, again passing into the obturator foramen, or extending into the acetabulum, or through the acetabulum into the greater sacro-sciatic notch. In these cases fracture of the descending rami of the pubes or ascending rami of the ischia on both sides is common. In falls from a height, when the patient strikes upon his buttocks, the tuberosity of the ischium may be broken off, or a fracture of the ascending ramus of the ischium may be produced, or a fracture may occur at the junction of the descending ramus of the pubis with the ascending ramus of the ischium. One of the commonest types of fracture is where a force acting from before backward creates a central fragment consisting of a greater or less portion of the pubic bones of either side, which are driven backward into the pelvis. If the violence was extreme and continues to act, the posterior portion of the ring may be broken upon one or both sides. The separation may occur through the sacro-iliac synchondrosis, or partly along this line and partly through the ilium, or the sacrum itself may be separated into two fragments, or a line of fracture may pass vertically through the ilium and end below at the sacro-sciatic notch. Such lines of fracture may occur upon one or upon both sides. When the violence acts in a frontal direction—that is, from side to side across the pelvis in such a manner as to crush the ilia toward one another—a fracture may be produced in the front part of the pelvic ring similar in situation to those already described, while posteriorly the sacro-iliac ligaments may be torn so that the joint gapes, or the sacrum may be fractured, or the ilium. In the latter case a line of fracture will run more or less vertically downward from the crest of the ilium to the sacro-sciatic notch. This constitutes what was described by Malgaigne as double vertical fracture of the pelvis. These several lines of fractures as described are considered more or less typical when the violence is exerted either directly from before backward, or from side to side. In many cases, however, the pressure upon the pelvic girdle is exerted obliquely and other lines of fracture may be produced. For practical purposes it is enough to know that fractures of the

pelvic ring occur along several more or less characteristic lines; and that, when the pelvic ring is fractured in front, a central fragment is often produced, which has its outer lines of fracture running into the obturator foramen with displacement backward, and that posteriorly the lines of fracture pass through the sacro-iliac joint, through the ilium, or through the sacrum itself in a more or less vertical direction. In the cases of double fracture the anterior line runs, as stated, somewhere through the horizontal ramus of the pubes and the ascending ramus of the ischium on one or both sides, while posteriorly, in classical cases, the fracture is through the ilium solely. It begins above, somewhere upon the crest, and ends below behind the acetabulum. In these, the central fragment may be movable and an upward displacement is commonly observed, so that the lower extremity appears shorter upon the injured side. Rotary displacement of the central fragment may also occur upon a horizontal or vertical axis.

Separation of the Symphysis Pubis and of the Sacro-iliac Joint.—Another group of cases best considered with fractures are the separations of the symphysis pubis and of the sacro-iliac joint. Separation of the symphysis pubis may be produced in several ways. It has repeatedly been observed during labor while the head of the child was passing the superior pelvic strait, and in these cases is produced purely by muscular action. In some of the cases the forceps were being used to deliver the head and the separation occurred while traction was being made. The diagnosis of this condition is usually very simple, and an audible snap has frequently been noticed at the moment of separation. A cleft between the bones is readily detected on palpation. Separation of the symphysis has also been observed as the result of violent abduction of both thighs, the injury in these cases being produced by traction through the adductor muscles. In other cases separation has occurred when an individual on horseback has been thrown forward onto the withers while making efforts to keep his seat.[1]

In a few cases separation has occurred both at the symphysis and at the sacro-iliac joint. Several kinds of violence may produce this injury. In the cases observed it has been caused by falls from a height upon one foot, by violent pressure from before backward over the ilium, occasionally from falls such that the individual landed upon one side of the pelvis. In these cases also an upward displacement has been observed, so that the whole ilium is elevated, together with the lower extremity.[2] Although these cases are extremely rare, the diagnosis might be established by the character of the displacement, by the absence of crepitation, and of the signs of fracture elsewhere in the pelvis, but more especially, as may be said of all fractures, by the skillful use of the X-rays.

Separation of the sacro-iliac joint without fracture is a very rare injury. Less than twenty observations of this dislocation, unassociated with fracture, have been observed. Stimson states (third edition, 1900, page 299) that he has

[1] L. A. Stimson, *loc. cit.*, 5th edit., 1907, p. 304.

[2] *Ibid.*, p. 305.

seen one well-marked case. The injury was said to have been produced during labor. The displacement was backward and outward. Here again the X-rays would probably furnish an accurate diagnosis in cases of doubt.

Separation of all three pelvic joints, not associated with fracture, is an injury the existence of which is doubtful. In all cases reported, and they are few in number, an associated fracture was present of one or other of the pelvic bones. All the cases were produced by extreme degrees of violence and all ended fatally.[1]

Isolated Fractures of the Pelvic Bones which do not Break the Continuity of the Pelvic Ring.—Among these, one of the most interesting is fracture of the acetabulum. The fractures of the acetabulum without separation of the pelvic girdle may occur of the rim of the acetabulum merely, or of the bottom of the cotyloid cavity. The first group of cases is always associated with dislocation of the femur. In these the symptoms are those of an ordinary dorsal dislocation. In addition there may be observed slight crepitation as the bone is replaced into its socket, and further that the dislocation may easily recur either immediately or after some hours. If the fragment of the bony lip of the acetabulum is of considerable size, it can be detected in an X-ray picture. The fracture of the bottom of the acetabulum may, as already indicated, be associated with fractures of the pelvic ring. In other cases, the head of the femur is driven into the bottom of the cavity in such a manner as to produce radiating lines of the fracture, or the head may be forced completely into the pelvis, so that the border of the great trochanter rests against the rim of the acetabulum. This last variety only occurs from blows or falls upon the trochanter, or in falls from a height, when the individual strikes upon one foot or upon the knee. The diagnosis of these cases is sometimes easy and sometimes difficult. Subjectively there may be great pain upon slight motion of the limb; in other cases, the femur is fixed and can scarcely be moved at all. Objectively the trochanter is less prominent than normal, suggesting an impacted fracture of the neck of the femur. The shortening is slight or absent. In a case which I recently saw in the New York Hospital, in the service of Dr. P. R. Bolton, the diagnosis was made by means of an X-ray picture. The head of the bone was driven partly through the acetabulum. The patient, a negro man of middle age, had fallen from a ladder a distance of fifteen feet, striking upon his hip. There was severe pain in the hip. Motion was restricted in all directions. The trochanter was notably flattened. The patient left the hospital at the end of a month with no marked improvement in his condition and on crutches.

In some of the cases previously reported the diagnosis of the nature of the injury was not made during life. In some, the amount of disability has been very great. The limb could not be moved without extreme pain, and motion has been absolutely restricted beyond certain limits. In others the amount of dis-

[1] L. A. Stimson, *loc. cit.*, 5th edit., p. 306.

ability has been much less and recovery has taken place with a good functional result.

Isolated Fractures of the Sacrum.—Isolated fractures of the sacrum may be produced from violence directed from behind forward, as from falls or blows upon the sacrum. The line of fracture is usually transverse and runs close below the border of the sacro-iliac joint. Comminuted fractures from great degrees of violence have also been observed. In almost all the cases the deformity has been an angular one, such that the tip of the coccyx pointed upward and forward. The injury is extremely painful, involving as it does laceration of, or pressure upon, some of the nerves passing through, or in front of the sacrum. Locally, there is extreme pain, both spontaneous and upon movement. There is apt to be marked interference with defecation and urination unless the fragment is replaced and kept in position. This latter is not always easy to do. Mobility and crepitation can usually be detected by grasping the lower fragment between the finger and thumb, the finger being introduced into the rectum. In many of the reported cases there have been more or less extensive paralyses of the lower extremities, as well as interference with the functions of the bladder and rectum. It may thus be seen that fracture of the sacrum may be a very serious injury indeed, and one easily recognized.

Fig. 37.—Dr. Bolton's Case of Fracture of the Floor of the Acetabulum and Penetration by the Head of the Femur.

Fractures of the Coccyx.—Fractures of the coccyx are probably extremely rare. The bone is so movable that when subjected to sudden violence it is much more apt to be torn away from the sacrum, or, in other words, dislocated than fractured. In the reported cases the details have been rather meager. It is, however, quite possible that some of the cases of coccygodynia following labor, or falls upon the buttocks, may have been due to fracture of

the coccyx. The history of the injury, localized pain and tenderness, crepitation and the recognition of undue mobility of the fragments by the introduction of a finger into the rectum, would be the best means of diagnosis other than an X-ray picture.

Fractures of the Ilium.—Isolated fractures of the expanded upper portion of the ilium, including the crest, are not uncommon. They are nearly always produced by direct violence and are often associated with marked contusion of the soft parts. A very few cases only have been reported in which the anterior superior, anterior inferior, and posterior superior spines have been torn away by muscular action. In the cases produced by direct violence the lines of fracture may run in various directions. They commonly begin somewhere along the crest of the ilium; in some cases even so far forward as below the anterior superior spine, and extend horizontally backward or backward and downward. The size of the fragments varies much in different cases. In some, merely a small portion of the crest of the ilium is separated. In others, a very considerable fragment exists; and in these the fracture may be comminuted to the extent that the separated piece may itself be broken into several fragments. The displacement in cases of fracture of a small portion of the crest may be very slight, or such a fragment may be displaced upward. If the line of fracture runs below the anterior superior spine of the ilium, the displacement is frequently outward and a little forward. If the anterior superior or anterior inferior spines are torn away as isolated fragments, they may be pulled downward by muscular action.

In the cases which have come under my observation, the fractures have usually been combined with severe contusions, so that the overlying soft parts were the seat of swelling and of extensive ecchymosis. One symptom produced is marked disability; the patients are often unable to walk on account of pain. Mobility and crepitation can usually be detected; though in some cases they are absent on account of the firm packing of muscles on either side of the line of the fracture, so that the fragments can be moved but little. It often happens when examining these cases that a slight change in the position of the patient will prevent the recognition of mobility, previously quite evident. In the examination it is important that the muscles should be as far as possible relaxed. For this purpose the patient should be placed with the body somewhat bent forward and the thighs flexed upon the pelvis (Stimson). In cases of doubt an X-ray picture taken with the injured ilium lying upon the plate and the rays passed obliquely through the bone from before backward should, as a rule, render the diagnosis clear.

Fractures of the Ischium.—Isolated fractures of the ischium are extremely rare. In the very few cases which have been reported the fractures took place from falls upon the buttocks, of a severe character, from a gunshot wound, in one case during labor, in which a previous fracture of the pelvis had caused a deformity such that the ischium was in the way of the fetal head. It was fractured during delivery. In some cases the fracture has been a sepa-

ration of the tuberosity. In these the fragment may be displaced downward by the attached muscles. In other cases the entire ischium may be separated and the outer and posterior line of fracture may or may not pass through the acetabulum. The displacement in these cases may be slight, but mobility and crepitation can usually be detected by ordinary methods of examination.[1]

Diagnosis of Fractures of the Pelvis in General.—From what has already been said, it may be understood that in general the diagnosis of fracture of the pelvis is not difficult. The history of the accident nearly always indicates a severe degree of violence. The patients often suffer from *shock*. Rupture of the bladder, or rupture of the urethra through the membranous portion, at the apex of the prostate, are very commonly associated injuries and give their own signs and symptoms. The reader will find them fully discussed in the sections on Injuries of the Bladder and of the Urethra, respectively. Associated injuries of the blood-vessels and of the nerve trunks are much more rare. The latter occur when fracture of the posterior portion of the ring takes place, either through or close to the sacrum. I have seen but one case of rupture of the iliac vein. The patient was a man upon whom I operated in the Roosevelt Hospital some years ago. He had received a typical crushing injury by being pinched between the buffers of two railway cars, and was brought to the hospital suffering from extreme shock. There was a severe contusion in the hypogastrium, fracture of the horizontal ramus of the pubes and of the ascending ramus of the ischium upon the right side, and a fracture which caused a partial separation of the left sacro-iliac joint below, and a nearly vertical line of fracture through the sacrum and ilium above, such that the upper angle of the ilium upon the left side remained attached to the sacrum. There were the signs of free fluid in the abdominal cavity. Though the man was in a desperate condition, I assumed the presence of a rupture of the bladder, though no blood had been passed *per urethram*, and opened his abdomen in the median line. The abdominal cavity contained a large amount of dark fluid blood. There was an extraperitoneal rupture of the bladder extending from near the peritoneal reflection downward and forward nearly to the prostate. The fractures were discovered upon examination as described. There was a partial rupture of the left common iliac vein. The patient died upon the operating table.

Naturally, ruptures of the bladder and injuries of the urethra are more common in cases of fracture of the pubic bone than in other situations. As already stated, these fractures usually involve the pelvic ring on both sides of the median line. Ruptures of the bladder are also frequent when the symphysis pubis is torn apart. Rupture of the bladder may also occur in conjunction with fracture of the sacrum and separation of the sacro-iliac joint. In some cases the rupture is produced by the same violence which causes the fracture. In others the bladder may be torn by the sharp end of a displaced fragment. (See also Injuries of the Bladder.)

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[1] Malgaigne, quoted by Stimson, *loc. cit.*, p. 313, 1907.

Rupture of the urethra nearly always occurs in the membranous portion. In fractures of the descending ramus of the pubes, when the force is exerted from side to side, the urethra may be literally cut in two. In other cases the very firm attachment of the membranous urethra to the symphysis pubis by means of the triangular ligament accounts for the rupture at this point, the symphysis forming a displaced fragment, the membranous urethra is torn away from the apex of the prostate. Among other associated injuries which will produce their own symptoms, but are rare, are injuries of the rectum and of the vagina. Injuries of the veins, either the large venous trunks of the pelvis or the prostatic and vesical plexuses, may be attended by fatal bleeding. Rupture of the external iliac artery has been observed in a few cases and has occurred presumably from overstretching of the coats of the vessel. One of the most deadly complications of fracture of the pelvis is suppuration, frequently of a necrotic character, of the loose connective tissues in the space of Retzius and the vicinity. A case of this kind which came under my observation is described under Injuries of the Bladder. In the slighter cases of fracture of the pelvis, such as separation of a portion of the crest of the ilium, or when other small and isolated portions of the pelvic girdle are separated from the main body of that ring, the symptoms are, of course, much less severe. They are to be recognized by the ordinary signs of fracture, and their exact situation and limits may be, in many cases, demonstrated by means of stereoscopic X-ray pictures. In the fractures which break the pelvic ring, and involve the separation of a central fragment in front, the displacement is usually easily recognized by inspection and palpation. In many cases the diagnosis is greatly assisted by palpation through the rectum or vagina, as the case may be.

The character of the displacement in fractures of different portions of the pelvis has already been mentioned. In some cases, where displacement is slight or hard to distinguish, ordinary methods of examination may leave the question in doubt as to whether a fracture exists or not. A fixed point of pain and tenderness and pain on passive motion of the thigh may be very suggestive signs and symptoms. In some cases the separation of a small bony fragment and its penetration into a muscular belly may cause extreme pain on motion and even spontaneous pain (Rose).

The differential diagnosis between fracture of the acetabulum and fracture of the femur should not, as a rule, be difficult, even without the aid of an X-ray picture. In fractures of the neck of the femur the limb lies extended and usually rotated outward. In fractures of the acetabulum, if the head of the bone has penetrated the bottom of the cavity, the trochanter should be much less prominent than in the case of an ordinary fracture of the neck, and yet the difference may not be sufficient for a diagnosis. In fracture of the rim of the acetabulum with dorsal dislocation upon the ilium, the main distinction from fracture of the femur lies in the position of the limb, which in a dislocation is flexed and rotated inward. In the case mentioned in the text the

differential diagnosis between fracture of the neck of the femur and penetration of the floor of the acetabulum by the head of the bone could not have been made without the aid of the X-rays. In both conditions there is usually absolute loss of function in the limb.

Prognosis.—It goes without saying that those fractures of the pelvic ring combined with severe associated injuries, either of the bladder and urethra or of other important structures nearby the seat of fracture, is extremely grave. If the associated injuries are not in themselves so serious as to cause immediate or early death, the prognosis will depend largely upon the promptness of surgical treatment, suture of the bladder, perineal drainage, incision and drainage of infected hematomata, reduction of displacement, etc. The simple fractures involving no lesions of viscera, blood-vessels, or nerves, usually recover promptly under suitable care. The prognosis of isolated transverse fracture of the sacrum, so commonly associated with serious injuries of nerve trunks, sometimes also of the bladder and rectum, is grave. In many cases death or permanent disablement will follow.

Gunshot Wounds of the Pelvis

Gunshot wounds of the pelvis occur with considerable frequency in battle; they are rare either as accidental or homicidal wounds in civil life. Their gravity depends, of course, upon the presence or absence of associated injuries of the contents of the pelvis and abdomen. Mere flesh wounds of the pelvic regions do not differ in gravity from those of other parts of the body and will depend upon the range, the character of the weapon, and upon associated injuries of blood-vessels and nerves, as elsewhere described. The same may be said of gunshot wounds involving the bones. The prognosis is also greatly influenced by the presence or absence of infection. Gunshot wounds of the *bones* of the pelvis depend for their gravity partly upon the presence or absence of extensive comminution of the bone with the commonly associated infection present in the former group, and, of course, also upon associated lesions of the pelvic viscera. A few peculiarities of gunshot wounds of the pelvis may here be noted. In general the remarks made under the head of gunshot wounds apply here. Old-fashioned leaden bullets fired from rifles of large caliber produce in the pelvic bones, as elsewhere, if the shot be at reasonably close range, extensive laceration of the soft parts and comminution of the bones. The high-powered military rifle bullet, on the other hand, if it strikes the thinner or more spongy portions of the pelvis, often passes through the bone, making an orifice not much larger than the diameter of the bullet. If, however, the harder portions of the pelvis are struck, as, for example, the massive bone structure surrounding the acetabulum, or the thicker part of the horizontal portion of the pubis, extensive comminution and widely spreading lines of fracture may occur. Among the most serious cases are those in which the upper portion of the femur as well as the pelvis receives the bullet.

In war, the soldiers on the firing line frequently lie prone. Sometimes, however, they are obliged to fire from the kneeling position. In these cases a more or less characteristic type of wound may occur. The bullet will enter the outer surface of the left thigh, perhaps at the knee-joint, or anywhere above that point, may fracture and extensively comminute the femur in its upward course and then enter and perforate the pelvis, frequently in the vicinity of the hip joint, or just above, emerging from the back. It can be readily understood that wounds of this character may be of a terrible description, the track of the bullet sometimes being twelve to eighteen inches in length. The amount of destruction of bone and laceration of the soft parts, to say nothing of the injuries of the pelvic viscera, may be very great. In many of these cases, however, the viscera will escape injury, since the wound of exit is frequently on the buttock and the track of the bullet does not pass through the pelvic cavity. Gunshot fractures of the ischium are often attended by great comminution.

In former wars it is noted that the most fatal gunshot wounds of the pelvis were those which entered from behind and where no wound of exit was present. The dangers in these cases depended upon the fact that such wounds were nearly always infected and that the wound canal ran through thick muscular layers, hard to drain. Wounds from in front which fracture the pubic bone also have a bad prognosis on account of the associated injuries of the pelvic and abdominal viscera. Gunshot wounds of the bladder are discussed under Wounds of the Bladder. The escape of urine from the wound affords, of course, an absolutely certain diagnosis. The recognition of wounds of the rectum depends upon the escape of feces from the wound, or of blood from the anus, more often upon the development of symptoms of sepsis, upon a septic cellulitis within the pelvis. In wounds uncomplicated by injury of the viscera, the structures wounded may usually be inferred, in case there is a wound of exit, from the direct course of bullets from high-powered rifles. The situation of the bullet, if lodged, can best be detected by means of the X-rays, either by stereoscopic pictures or by the use of one or other of the forms of localizer. (See Dr. Sweet's Localizer, Vol. I.)

Recovery from complicated gunshot wounds of the pelvis may occur under apparently the most unfavorable conditions. I knew a man who had been shot, during one of the battles of the Civil War, through the pelvis from side to side. The bullet entered the right hip, passed through the ilium, crossed the abdominal cavity, and embedded itself in the ilium of the opposite side. The bullet was an ordinary minie bullet. It was extracted later by incision at the bottom of an abscess cavity which developed in the left iliac fossa. The man had made, when I knew him, a perfect recovery.

The lodgment of bullets in the pelvis, or in the soft parts which surround the pelvis, is, so long as no pelvic viscus suffers injury, and infection does not take place, a matter of no great moment. If, however, infection of such wounds occurs, the bullet may remain at the bottom of a suppurating cavity indefinitely, unless extracted. Some years ago I removed a leaden bullet which was embedded in the ilium above the acetabulum. This bullet had

been received during the Civil War, at the battle of Antietam or Sharpsburg, and had remained at the bottom of a suppurating tract, which healed from time to time and again broke down, during a period of more than twenty-five years. After the extraction of the bullet and the removal of the infected tissues the wound healed permanently. Splintered fragments of bone from gunshot wounds of the pelvis may enter the bladder at the time of injury, or subsequently by ulceration, and may form the nuclei of vesical calculi.

Shell wounds of the soft parts or bones of the pelvis are often very extensive lacerated wounds with comminution of the bones, and such, of course, are frequently fatal. During the Civil War in America it sometimes happened that a soldier was struck by one of the large iron shells then in use in navy guns and in fortifications, and that the body of the individual was cut completely in two. A case of this kind is narrated in "Battles and Leaders of the Civil War," where two soldiers, being on a marsh and, as they believed, out of range of a heavy cannon mounted on a fortification, one of them challenged the fort to fire at him by certain peculiar gestures, believing himself so far away as to be out of danger. The challenge was accepted, and the shell which arrived cut his body completely in two.[1]

Coccygodynia

Under the name of coccygodynia we understand a painful affection of the lower end of the spine, observed much more often in women than in men; and usually without discoverable lesion of the bones or the soft parts. The condition is most often observed in neurasthenic individuals, although it may occur among those who appear to be in good health. It has been attributed to a variety of causes, among them injuries to the coccyx, or to the joint between the coccyx and the sacrum, or to the ligaments or nerves, occurring during difficult, or instrumental delivery of the fetus. It may also follow falls and blows upon the coccyx; and occasionally develops without history of injury or other assignable cause. The symptom is *pain*, referred to the region of the coccyx during defecation, or produced by muscular movements, such as the act of rising from the sitting posture. The pain is rendered worse by pressure, as when the individual sits down upon a hard chair. Some of the cases are purely neurasthenic. I have seen several of them cured by hygienic measures and the use of drugs having a sedative action upon the nerves, notably asafetida. In some cases no treatment short of the removal of the coccyx is beneficial. If, however, a patient is markedly hysterical or neurasthenic, the wise surgeon will give a guarded prognosis as to the certainty of cure following the operative removal of the bone.

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[1] The incident is described as having happened during the siege of Fort Pulaski, Georgia. The shot was fired from a Blakely rifled gun (English). It was said that the gun was sighted by the colonel in command of the fort. "Battles and Leaders of the Civil War," The Century Company, vol. ii, p. 4.

DISEASES OF THE PELVIS

Acute Osteomyelitis of the Pelvic Bones

The general and local symptoms of acute osteomyelitis have been fully discussed in the section devoted to that disease. As was there stated, acute osteomyelitis is far less common in flat than in long bones, and indeed acute osteomyelitis of the pelvis is rare. Of all the portions of the pelvic girdle the ilium is more often attacked than any other part. In a certain proportion of cases the disease follows subcutaneous injury, often of slight severity, although it is difficult to say in many cases, whether the injury itself has any direct causative relation to the inflammation of the bone. In the cases which develop two or three months after a slight contusion of the pelvis, it is highly probable that no such relation exists. As with osteomyelitis elsewhere, the disease occurs during childhood in a large proportion of cases. The infection of the bone may be limited to some particular portion, or may be diffuse. A favorite localization appears to be the lines of union of the several bones in the acetabulum. The sacrum is much less often involved than the ilium.

Symptoms.—The general signs and symptoms of acute osteomyelitis of the pelvis do not differ from those observed in the long bones. The picture is often one of an intense and rapidly fatal sepsis, in the face of which surgery finds itself quite helpless. *Locally*, pain, swelling and tenderness are to be observed. When the disease is located in the vicinity of the acetabulum, the clinical picture may closely resemble an acute suppurative inflammation of the hip-joint. The more violent the general symptoms and the greater the amount of local pain, the more probable the diagnosis of osteomyelitis. If the patient survives a week or two, local signs of swelling, enlargement of the subcutaneous veins, tenderness—in other words, the signs and symptoms of deep-seated suppuration—will become evident. In the less severe cases the condition may remain obscure for a considerable period; as when a focus is limited to a portion of bone, not readily accessible to palpation, for example, to the inner aspect of the ilium. In these cases, localized pain and tenderness, a continued fever with evening exacerbations, leucocytosis, with relative increase of the polymorphonuclear cells, will enable the surgeon to arrive at a probable diagnosis of a suppurative lesion. Sooner or later, if the patient survives the general septic poisoning, an abscess will develop, giving the ordinary signs and symptoms, which, if it be allowed to break, or be incised, will permit the escape of pus, usually containing Staphylococcus pyogenes aureus. At the bottom of such an abscess will be found exposed bone. More or less extensive necrosis, with the formation of a sequestrum, follows. In a large proportion of cases the sacro-iliac or the hip-joints are involved. If these children survive, the development of that side of the pelvis is interfered with, the sacro-iliac joint is destroyed, the hip-joint is frequently in a state of bony ankylosis, usually in marked adduction and flexion. The pelvis exhibits an oblique deformity, owing

to the imperfect growth of the bones of half the pelvic ring. The outlines of the bones of the affected side are changed, their surfaces are roughened and may be covered with osteophytes. All the pelvic diameters are diminished, and if the individual be a woman, insurmountable obstacles to normal delivery will nearly always be present.

Recently I saw a case of chronic osteomyelitis of the left ilium which followed an infected gunshot fracture of the right femur. The infection had invaded and caused ankylosis of the left hip-joint. A sinus led to dead bone in the left iliac fossa.

Tuberculosis of the Bones and Joints of the Pelvis

Primary tuberculosis, originating in the bones of the pelvis, is a rare condition. It is probable that a small proportion of the cases of tuberculous arthritis of the hip-joint arises, not in the femur, but in the ilium, near the joint, which the disease subsequently invades. The clinical picture in these cases will be that of tuberculosis of the hip-joint, elsewhere discussed. In cases of disseminated tuberculosis of the bones and joints, it occasionally happens that a tuberculous focus develops in the pubis, or in some portion of the ilium not situated near a joint. The history of these cases will be, usually in the presence of tuberculous foci elsewhere in the body, the gradual formation of a painless swelling, ending in the development of a cold abscess leading to bone, the seat of tuberculous caries and tuberculous periostitis.

Tuberculosis of the Sacro-iliac Joint; Sacro-iliac Disease; Sacro-coxitis.—Tuberculosis of the sacro-iliac joint is one of the rarer sites of tuberculous arthritis. The disease is infrequent in children, is rare before the end of the second decade, and is most frequent between the ages of twenty and thirty-five years, although cases are sometimes observed during advanced life. The primary focus is, almost without exception, in the sacrum, with secondary involvement of the sacro-iliac articulation. The disease here, as elsewhere, is characterized by a slowly progressive, destructive lesion of the bones and soft parts entering into the joint. *Clinically*, the progress of the disease is often insidious, and the condition may exist for months, or even years, before a definite diagnosis is made. After a certain time there is regularly produced a cold abscess, which may present posteriorly in the lumbar region, above the joint, or farther down over the joint itself. In some cases the tuberculous abscess appears beneath the muscles of the gluteal region and reaches the surface near the gluteal furrow. In still other cases the abscess forms on the anterior surface of the sacrum and may then be palpable *per rectum*. The early symptoms consist of pain, very commonly referred to the sacro-iliac joint, though in many cases the pain radiates downward in the distribution of the great sciatic nerve. Therefore, in its early stages, the occurrence of the *symptoms of sciatica*, which persist, resisting ordinary methods of treatment, should lead to a suspicion of sacro-iliac disease and a careful examination of the pelvis, in order, if possible,

to exclude this condition. In some cases the pain may radiate forward and be referred to the anterior superior spine of the ilium, or to the anterior surface of the thigh. The pain is increased by motion of the joint, and by pressure, either posteriorly or anteriorly, *per rectum*. Walking becomes difficult and painful, and even the prolonged sitting posture in one position may cause an aggravation of the pain. The pain is usually worse on standing, better when the patient lies upon his back, though frequently severe pain at night is complained of. *By pressure upon the crests of the ilia, such that the diseased joint surfaces are crowded together, the pain is increased.* The attitude and gait of these patients is peculiar, and sometimes characteristic. When standing erect, the pelvis is rotated on a horizontal axis downward upon the affected side, producing an apparent lengthening of the lower extremity of that side. Though this is the rule, rotation in the opposite direction is occasionally observed. When walking, the patient leans a little forward and often supports himself by means of a cane. The gait is a shuffling one; the feet are held close together and are not lifted far from the ground; the steps are short. There is frequently added a fairly marked lateral deviation of the spine. If untreated, or not favorably influenced by treatment, there develops in the course of months or years a cold abscess which approaches the surface in one of the situations already mentioned, or farther down upon the posterior surface of the thigh. If the abscess ruptures, or if it be incised, and in either case pyogenic infection follows, there are added the symptoms of chronic sepsis elsewhere described.

Differential Diagnosis.—The two conditions with which sacro-iliac disease is most likely to be confounded are *sciatica* and *tuberculosis of the hip-joint*. The following considerations may aid in the diagnosis: Sciatica of a marked and persistent type is a disease rather of middle age or later life; whereas, disease of the sacro-iliac joint is more common during an earlier period. In sciatica the trunk of the sciatic nerve itself is usually tender. Pressure upon the pelvis, such that the surfaces of the sacro-iliac joint are crowded together, increases the pain of sacro-iliac disease, but has no influence of this kind in sciatica. Careful palpation over the joint posteriorly and *per rectum* should never be omitted in cases of long-continued sciatica. From tuberculosis of the hip-joint, sacro-iliac disease is to be differentiated from the following observations: The deformity of the spine and the abnormal position of the pelvis disappear in sacro-iliac disease when the patient lies down, or may be made to disappear by placing him in a suitable posture. There is no limitation of motion in the hip-joint, this consideration alone being sufficient in most instances to exclude tuberculous coxitis. After a tuberculous abscess has formed, the diagnosis may be rendered very simple, though in some cases it will be necessary to exclude other causes of suppuration connected with the bony pelvis. These will be considered in another place. In doubtful cases the X-rays may aid in the diagnosis, if the disease is far advanced.

Syphilis of the Bones of the Pelvis

Syphilitic Osteitis and Periostitis of the Pelvic Bones.—Syphilitic inflammation of the pelvic bones is one of the rarer localizations of the disease. It is characterized here as elsewhere, by an infiltration of the bony structure with gummatous material and by an inflammation, partly formative and partly destructive. The symptoms of syphilitic inflammation of bone are present—namely, pain and moderate tenderness. The pain, however, is much less severe than is commonly observed in the frequent syphilitic inflammations of the long bones, notably of the tibia. In the presence of other syphilitic manifestations, the formation of gummata connected with the pelvis, with an accompanying swelling, is usually easy to recognize and to interpret. In the absence, however, of other active lesions, or of a history of syphilis, the diagnosis is frequently difficult. If the process occurs in a superficial part of the pelvis, and a palpable tumor is formed, the diagnosis of a true new growth is often made. One of the *favorite sites* for syphilitic inflammations of the pelvic bones is along the *crest of the ilium*. The signs are, thickening of the bone, the formation of a somewhat cylindrical enlargement, of a slowly progressive character. When the syphilitic process, wherever situated, eventuates in softening and the formation of a gummatous abscess, the characteristic appearances observed, after incision, or after spontaneous ulceration, are those of broken-down gummata, easily recognized by the experienced eye. (See Syphilis.)

Diagnosis of the Origins of Abscesses which Approach the Surface in the Vicinity of the Pelvis

As already mentioned, the tuberculous, or other abscesses, associated with disease of the sacro-iliac joint may approach the surface above the crest of the ilium and in close juxtaposition to the upper limit of the sacro-iliac joint, or, on the other hand, they may burrow beneath the muscular layers and appear in the buttock, or in the gluteal furrow, or even farther down upon the posterior surface of the thigh. When the abscess burrows in a *forward direction*, it may be palpable as a fluctuating swelling *per rectum* and may reach the surface in the gluteal furrow, having escaped from the pelvis through the sacro-sciatic notch, or, on the other hand, may make its way into the ischiorectal fossa and present upon the surface of the buttock like an ordinary ischiorectal abscess. Those intrapelvic abscesses which follow the course of the *iliacus muscle* may present in the fold of the groin, just below Poupart's ligament, where the iliacus muscle passes from the pelvis down into the thigh. In other cases, these abscesses approach the surface lower down, and then the belly of the sartorius muscle forms a barrier, such that the abscess approaches the surface at some point either just internal to or just outside of the course of this muscle. It is to be borne in mind, that not only these abscesses following the

course of the iliacus tendon, but also psoas abscesses may invade and secondarily infect the hip-joint.

Abscesses originating in tuberculous caries, or acute osteomyelitis of the dorsal and lumbar vertebræ, follow the course of the psoas muscle, so that when they approach the surface in the thigh, it is at a point considerably internal to those following the course of the iliacus muscle, as already described. The typical position for a psoas abscess, which appears below Poupart's ligament, is somewhere not far from the mid-line of Scarpa's triangle. A psoas abscess may also form a fluctuating swelling above Poupart's ligament and, as elsewhere described in this book, it may then be possible by pressure, first above Poupart's ligament and then below, to appreciate a sense of fluctuation, according as the tension of the pus is increased in the intra- or extra-abdominal portion of the sac. (See Diseases of the Abdomen.)

There remain a number of conditions under which large collections of pus occur in the iliac fossa, and the lower lateral quadrants of the abdomen. Many of these abscesses are associated with special lesions, which give their own symptoms, as, for example, inflammation of the vermiform appendix and the various inflammations resulting in abscesses of the uterine adnexa. Such collections may also arise from the kidney, notably in cases of tuberculosis of that organ, or from other retroperitoneal organs or structures. The diagnosis of these conditions may often be made from concomitant signs and symptoms, referable to such organs. In other cases, however, no diagnosis will be made until the abscess is incised and its origin sought for, by palpation of the cavity, or the introduction of suitable exploring instruments.

Aneurisms of the Groin

Under this head are ordinarily included aneurisms forming upon the external iliac, or the common femoral artery, and the two main branches of the common femoral—namely, the superficial femoral and the profunda. These aneurisms are grouped together, not only because they arise in the same general region and have many signs and symptoms in common, but also their surgical treatment is quite similar.

The external iliac artery begins opposite the sacro-iliac joint, at the bifurcation of the common iliac. It lies upon the inner margin of the psoas muscle, is covered by peritoneum, and passes to the middle of Poupart's ligament. Below this point it is known as the femoral artery. The vein lies to its inner side. The common femoral divides into its two branches, the superficial femoral and the profunda, at a distance of one or two inches below Poupart's ligament in Scarpa's triangle. *Traumatic aneurisms* of the external iliac and common femoral arteries are extremely rare, the reason being that while wounds of these vessels are fairly frequent, an aneurism has seldom time to form, since the injured individuals usually bleed to death.

The *spontaneous aneurisms* of the groin have for their causation, degeneration of the arterial wall, produced by syphilis, alcoholism, nephritis, possibly also by the constitutional disturbances accompanying chronic gout and rheumatism, which produce arteriosclerosis. Chronic alcoholism undoubtedly causes arteriosclerosis in persons not yet advanced in years and thus favors the occurrence of aneurism. In a certain proportion of cases, traumatism, whether from blows or falls, or from a sudden stretching of the arterial tube, precedes the formation of the aneurism. Of the aneurisms in this region the largest number originate in the common femoral, next in the external iliac, and lastly in the branches of the femoral close to their origins, aneurisms of the internal iliac artery being extremely rare. The disease affects men much more often than women in the proportion of almost 20 to 1. The aneurismal tumors are usually not very large. They may be as large as a hen's egg, occasionally as large as a goose egg, seldom very much larger. Aneurisms situated below Poupart's ligament are usually globular in shape. When they form above Poupart's ligament in the iliac fossa, they vary in shape and may be either spindle-shaped or globular. The aneurisms of the superficial femoral commonly have a spindlelike form.

Symptoms and Diagnosis of Aneurisms of the Groin.— Following some injury, or a muscular strain of the groin, but in the majority of cases without any such

FIG. 38.—ANEURISM OF THE FEMORAL ARTERY. Acute endocarditis. Gangrene of the foot and leg. (New York Hospital, service of Dr. Conner.)

history, the patient may notice, as the first symptom, a sharp pain referred to the affected region. In other cases no pain will be present, but simply the formation of a small tumor connected with the artery, which, however, increases rather rapidly in size. The ordinary symptoms of aneurism are present—i. e., expansile pulsation and bruit. If it is possible to compress the artery between the aneurism and the heart, pulsation in the sac will cease and the aneurism may diminish somewhat in size. Pressure symptoms are sometimes produced,

edema of the extremity from pressure upon the vein, sometimes neuralgic pain from pressure upon the nerve trunks. Here, as elsewhere, aneurisms tend to invade and cause absorption of surrounding structures. Thus, absorption of some portion of the pelvic bones pressed upon by the aneurism may take place, or interference with the functions of the hip-joint. After a certain time the aneurism may rupture either internally into the abdominal cavity, or beneath the peritoneum, or in the intermuscular planes of the thigh, or in the subcutaneous tissues, with the production of a tumor, or with widespread infiltration with blood. The aneurism may cause pressure ulceration of the overlying skin and rupture externally, with a fatal result. If the rupture is small, bleeding may at first be moderate and may cease by clotting; but the hemorrhage will recur, and sooner or later cause death. Infection of the aneurismal sac may occur and be followed by suppuration, sometimes by gangrene of the limb from pressure, or death from hemorrhage. In inquiring into the history of an aneurism, it is important to discover where the original tumor formed and thus the origin of the aneurism. This knowledge is an important aid in deciding as to the site and sometimes the method of operative treatment. There is very little tendency on the part of aneurisms of the iliac and femoral arteries to undergo spontaneous cure. The tendency is toward increase in size and final rupture. I have seen a number of cases in which the aneurism ruptured into the tissues of the thigh and in every one with a fatal result, either from gangrene of the extremity or from hemorrhage. As has been mentioned when discussing aneurisms in general, a mistaken diagnosis is by no means rare. If the aneurism is inflamed and about to rupture, it may present the appearance of an ordinary abscess, and if the sac is thickened or partly filled with clots, the characteristic signs of aneurism may be absent, or hard to appreciate. Such aneurisms have repeatedly been incised under a mistaken diagnosis, with a fatal result.

Aneurisms of the Buttock

The internal iliac artery gives off anterior and posterior branches; the largest branch of its posterior division is the *gluteal artery*, which emerges from the pelvis through the upper part of the greater sacro-sciatic foramen. The artery soon after it emerges, divides into superficial and deep branches; the superficial branch passes between the gluteus maximus and medius muscles in an outward direction. The deep branches run between the gluteus medius and minimus. The anterior division of the internal iliac gives off the *sciatic artery*, which emerges from the pelvis, through the lower portion of the greater sacro-sciatic foramen, along with the great sciatic nerve. The artery follows the nerve downward for a short distance and gives off lateral branches which are distributed to the structures in the vicinity. Aneurisms may develop upon either the *gluteal* or the *sciatic* arteries. A very large proportion of them are of traumatic origin. In the small group, which appears to be spontaneous, the

same predisposing causes exist as result in aneurisms elsewhere. In many of the *traumatic cases* following stab or punctured wounds of the gluteal region, the condition produced is rather that of *primary arterial hematoma* than that of aneurism in the stricter sense. In this group of cases, following a narrow through deep wound of the buttock, there will be in some, severe external hemorrhage, which will at once lead to a suspicion of a wound of a large arterial trunk. In others, the external bleeding may be slight from the first, or, if at first profuse, it will soon cease. In these cases there will develop, usually quite rapidly, a tumor in the gluteal region, sometimes of considerable size, which increases from day to day. If the wound of the artery was incomplete, the tumor will show, upon auscultation, the presence of a whirring murmur, synchronous with the arterial pulse. The *treatment* of these cases is broad incision, evacuation of the clots, and control of the arterial hemorrhage by ligature. An arterial hematoma has been observed following injuries of the perineum, such as occur from impalement. The condition has been sufficiently described under injuries of the perineum.

As to the *diagnosis* in general of aneurisms of the buttock, it may be said, that after any severe injury to this region, whether accompanied by an open wound or not, in which a considerable tumor soon develops, the surgeon should always think of the possibility of aneurism. In the cases which follow subcutaneous injuries or open wounds, the appearance of aneurism is not always immediate. The development of the tumor to appreciable size may require a number of weeks.

Symptoms of Gluteal Aneurism.—In addition to the formation of a tumor, *pain* is a prominent symptom. Pain occurs in the distribution of sciatic nerve chiefly, and may, therefore, be felt in the back of the thigh, leg, or foot, or, when other nerves are compressed, in the pelvis, or in the perineum. The diagnosis of sciatica is sometimes made. The sac of a gluteal aneurism seldom reaches a very large size before rupture occurs into the tissues of the buttock. In other cases a very considerable tumor has been slowly formed, as large as an orange, or even as a child's head. While in general the signs of aneurism are perfectly distinct, the condition has been mistaken for an abscess, for sarcoma of the buttock, or of the pelvis. The differential diagnosis is to be made by the use of an aspirating needle, by the history, by the absence of an irregular knobby contour, such as is observed in sarcomata of this region; and by rectal examination, in the search for evidences of disease of the pelvic bones, or other lesions. The absence of the constitutional symptoms of sepsis should enable the surgeon to avoid mistaking an aneurism for an acute abscess. In malignant tumors of the bone it is often possible, upon palpation, to detect the actual enlargement of the bone and sometimes the peculiar parchmentlike crackling felt when pressure is made upon the thin layer of bone which may cover a central sarcoma. In such a case the X-rays would aid in the diagnosis. The differential diagnosis between aneurisms of the gluteal and sciatic arteries can scarcely be made unless the aneurismal tumor is very small. In the latter case an aneurism of

iatic artery would occupy a lower position than that originating in the al. The former would be situated near the greater sacro-sciatic notch, latter lower down near the tuberosity of the ischium.

Tumors of the Pelvis

We have already described the tumors which occur in the sacrococcygeal egion, and which may, as stated, develop either in front of or behind the acrum and coccyx. (See Spine.) In addition, there remain to be described the tumors growing in the pelvic bones and those occurring in the soft parts outside the pelvis, as well as those occurring in the soft parts the interior of the pelvis; excluding the tumors which develop in the connective tissues in viscera and which have received attention under appropriate headings. The tumors occurring in the soft parts surrounding the pelvis are more frequent upon the buttock than elsewhere. Most of the ordinary varieties of tumor may occur in this region—lipoma, fibroma, sarcoma, myxoma, as well as several forms of cystic growth—namely, ordinary atheromatous cysts and dermoids.

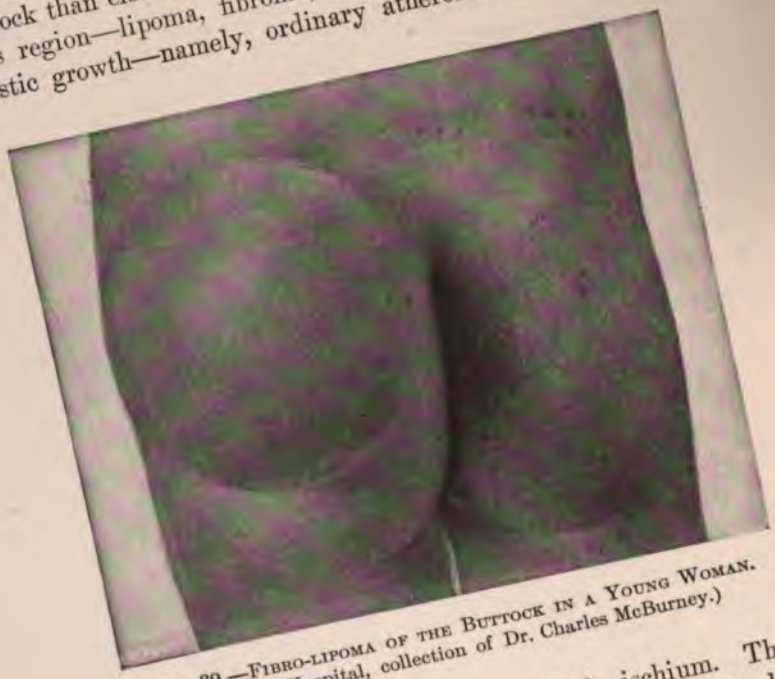

Fig. 39.—Fibro-lipoma of the Buttock in a Young Woman. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

Bursæ may rarely develop over the tuberosity of the ischium. The diagnosis of these several forms of growth presents, as a rule, no great difficulties. The history and appearance of the tumors does not differ from similar growths in other parts of the body.

Tumors of the Bones of the Pelvis.—The most important tumors developing bones of the pelvis are fibroma, osteoma, enchondroma, and sarcoma rather rare tumors. The sarcomata are by far the m

frequent. While these tumors do not differ in their characters from similar tumors elsewhere, there are a few special data which may here be mentioned. The special characters of the tumors of the pelvic bones are as follows: The fibromata and true bony tumors are benign, although with the former, combinations with sarcoma may occur. The fibromata occur most often in women and their favorite site is the vicinity of the anterior superior spine of the ilium, whence they may grow outwardly or backward into the iliac fossa. They develop usually from the connective tissues or from the periosteum of the bone. They are usually smooth, hard, rounded tumors, occasionally soft, and in them myxomatous as well as sarcomatous degeneration may take place.

FIG. 40.—SARCOMA OF THE ILIUM. (New York Hospital, service of Dr. Frank Hartley.)

The favorite site of the *osteomata* and of the *enchondromata* is the ilium, near the sacro-iliac joint; whence the tumors usually grow forward. The osteomata are slowly growing tumors of a generally rounded contour, though often with a knobby and uneven surface, and of bony hardness. The same is true of the enchondromata, except that the latter, after they have existed for a considerable time, *may form metastases* in different parts of the body. The differential diagnosis between bony and purely cartilaginous tumors can be made with absolute certainty, if the tumor is favorably situated, by means of the X-rays. Bony tumors cast definite shadows in which frequently the structure and arrangement of the bony lamellæ constituting the growth are plainly shown upon the photographic plate. Cartilage, on the other hand, casts a shadow so faint that it is hardly distinguishable, even by the most careful technic. This difference alone is sufficient for a differential diagnosis if the tumor contains bone or cartilage exclusively. Both bony and cartilaginous tumors may be solitary or multiple. Combinations of cartilage and bone may occur in the same growth. Bony and cartilaginous tumors may, so long as they remain small, give few or no symptoms. If they attain to considerable size, they may

produce symptoms of various kinds by pressure upon nerve trunks, or upon intrapelvic organs. It not infrequently happens that bony and cartilaginous tumors are observed in several situations of the body at the same time; so that if a woman who is pregnant exhibits exostoses of the long bones or elsewhere, it is always wise to make an intrapelvic examination for the purpose of excluding bony outgrowths into the interior of the pelvis, which might seriously interfere with delivery. This will be especially true when, as sometimes happens, these tumors grow from the posterior surface of the pubic bone or from the ischium.

Sarcoma.—Sarcoma may develop from the periosteum, or from the medulla of the bones. All the different varieties of sarcoma may develop in connection with the pelvis, as well alone, as in combination with bony tumors, fibroma and myxoma. The periosteal sarcomata of the pelvis are frequently less malignant forms and may remain covered by a fibrous capsule for a long time, and when accessible may be removed with a fair degree of ease and some hope of cure. Those growing in the interior of the bone are often very vascular tumors of rapid growth, which soon cause destruction and perforation of their bony covering and may exhibit pulsation and even a murmur. They are often mistaken for aneurisms, notably when they grow into the interior of the pelvis.

These tumors may develop at any period of life, and in general their history resembles that of other sarcomata. The course of the disease is slow, or rapid, according to the character of the individual tumor. Metastases occur as in other sarcomata, notably in the lungs. As to the physical characters of the tumors themselves, I have very little to add to what has been stated under tumors in general. When accessible to palpation they form rounded, sometimes knobby growths, sometimes hard, sometimes soft, suggesting fluctuation, and sometimes of uneven consistence. If the tumor causes expansion of the bone, parchmentlike crackling may be distinguished over its surface with the fingers. The X-rays are a valuable aid in the diagnosis. Secondary tumors frequently form in the vicinity, and if the growth approaches the skin such nodules may be felt in the muscles, in the subcutaneous tissues, or in the skin. It occasionally happens that the tumor perforates the skin with ulceration, hemorrhage, etc. Depending upon their situation, these tumors may grow to a considerable size before they are discovered, or, on the other hand, if so situated that they press upon the nerve trunks of the lumbar or sacral plexuses, pain will be an early symptom, which slowly or rapidly grows worse and involves larger areas of distribution of sensory nerves. The pain is referred to the distribution of the affected nerves and thus may be felt in the back, in the groin, in the perineum, down the thigh, or in the leg and foot. The pain will often at first be mistaken for sciatica, and it is noteworthy that *the onset of the pain in malignant tumors of the pelvis may be absolutely sudden*, thus tending to a false diagnosis at the start. In addition to the pain, there may follow palsies of groups of muscles and, finally, disturbances of the function of the bladder and rectum, which soon destroy life. The pain in many cases is so unbearable that these patients early acquire the morphin habit.

Cystic Tumors in the Cavity of the Pelvis.—The tumors which occur in the connective tissues of the interior of the pelvis are chiefly those cystic tumors occurring in front of the sacrum and believed to originate in a persistent remnant of the connection between the epithelial lining of the medullary canal and the postanal gut, already described under the head of sacrococcygeal tumors (see Spine), or they are echinococcus cysts.

Echinococcus cysts of the pelvis occur occasionally in those countries where the disease is endemic. They may occur within the pelvis, in the soft parts surrounding the pelvis, or in the pelvic bones. As is the case with echinococcus cysts elsewhere situated, the tumors are of a slow growth. In general, the diagnosis made before operation is scarcely likely to be nearer the truth than is involved in the assumption that a cystic tumor of some sort is present. When the growth originates in the bone the signs and symptoms would closely resemble a slowly growing central sarcoma. A certain diagnosis is only likely to be made at the time of operation, or upon aspiration of the fluid contents of the cysts with the recognition of the hooklets.

The prognosis of echinococcus of the pelvis depends upon whether the disease originates in the soft parts and in a position accessible to the knife, or in the bones. If the tumor is readily accessible, even though it be in the lesser pelvic cavity, the prognosis for cure is good. If it originates in the bone, the prognosis is much less favorable. The conditions for a radical cure by operation in this latter case are usually difficult.

As already noted, the diagnosis of pelvic tumors attached to or involving the bone may be greatly assisted by means of the X-rays. The bony destruction produced by sarcomata may be very perfectly shown by a good X-ray picture. In the case of the bony and cartilaginous tumors growing from the ilium, near the sacro-iliac joint, forward into the pelvic cavity (their favorite mode of growth), the X-ray diagnosis is not so satisfactory. The tumor is too far away from the plate to cast a definite shadow. In the cases which involve the anterior portion of the pelvic ring, the diagnosis of the tumor by ordinary methods of palpation is usually possible. It will be greatly assisted by the X-rays. In addition to the differences already noted between bony tumors and those composed of cartilage, it is to be borne in mind that while the cartilaginous tumors in their early stages remain hard with a knobby, uneven surface, later they may degenerate so that harder and softer areas may alternate upon the surface of the tumor. The differential diagnosis between the various forms of pelvic tumor, aneurisms, hernias through the sacro-sciatic foramen, abscesses which point here, or echinococcus cysts which make their way out of the pelvis through this outlet and their various characters, will be found sufficiently described under proper headings, and I do not feel that a further discussion of these conditions is called for in this place.

CHAPTER VII

CONGENITAL DEFECTS AND INJURIES OF THE SHOULDER AND VICINITY

CONGENITAL DEFECTS OF THE SHOULDER REGION

Congenital Defects of the Clavicle.—Congenital defects of the clavicle, either unilateral or, more commonly, bilateral, are very rare. The clavicle may be entirely absent on one or both sides, or the defect may be confined to one or both ends of the bone, a central rudiment being formed. The diagnosis of the condition offers no difficulties, on palpation the collar bone is found absent. The deformity produced is often very slight, since the muscles in the vicinity of the shoulder-joint and in the neck, tend to hold up the shoulder-blade and humerus. Some falling of the shoulder, however, is commonly present. In bilateral cases the mobility of the upper extremity is greatly increased, so that, for example, the inner surfaces of the upper arms may be brought into contract in front of the sternum.

Congenital Elevation of the Scapula—Sprengel's Deformity.—Congenital elevation of one or both scapulæ is a deformity of not very rare occurrence. The most complete collection of data in regard to this topic have been accumulated and embodied in a short monograph by A. E. Horwitz, printed in the *American Journal of Orthopedic Surgery*, November, 1908. Horwitz was able to collect 120 cases from the literature, to which he added 16 unpublished cases. The deformity is usually unilateral in the proportion of about 10 to 1. The most marked and evident sign of the condition is an *abnormally high position of the bone.* In addition, the bone of the affected side varies from its fellow in shape. There is a diminution in the vertical diameter of the bone and an increase in its horizontal diameter. The scapula, in this respect, retains the shape observed *in the fetus and approaches that which is normal in some of the quadrupeds.* In a certain proportion of the observed cases there is a bending forward of the supraspinous portion of the body of the bone. In addition, there is quite constantly observed a prolongation of the superior median angle of the scapula, such that this portion of the bone was formerly, until the nature of the deformity came to be understood, frequently mistaken for an exostosis. In about twenty-five per cent of the cases this prolongation extends toward the median line of the back and is attached by fibrous tissue, or cartilage, or bone to the transverse process of a cervical vertebra (from the fourth to the seventh). Associated with the deformity of the scapula there is

frequently observed *scoliosis*, which may be to one or the other side. Defects of muscles may also coexist, the most common defect being a *weakness* or *imperfect development* of the *trapezius muscle*. In one or other of the reported cases defects have been observed in almost all of the muscles attached to the scapula. The *clavicle* may be shorter than normal, or longer than normal, or malformed. The *humerus* may show evidences of arrest of development in that it is not as long as its fellow. In a considerable proportion of cases other congenital defects have been observed. The most common of these are, *imperfect development of one side of the face*, wry-neck, club-feet, and asymmetry in the lower extremities of the two sides of the body, together with a number of other associated congenital deformities in isolated cases. The defects are more apt to occur upon the same side of the body as the elevation of the scapula.

The *height of the scapula above its fellow varies* in different cases and at different ages. During childhood the difference upon the two sides is, of course, less than in adult life. The following figures are given by Horwitz. At the age of 1 to 5 years the average elevation was 3.4 cm. The minimum was 1.0 cm. The maximum was 5.5 cm. Between the ages of 15 and 20 years the average height was 5.8 cm. The minimum was 2.5 cm. The maximum was 12.0 cm. In a large proportion of the cases observed the scapula retained its infantile shape and size and did not keep up in growth with the rest of the body. The scapula may or may not be rotated upon a sagittal axis. The *inferior angle* of the bone is usually *rotated forward*, so that it is farther away from the median line of the body than normal. In some cases the bone is also rotated upon a frontal axis so that it flares away from the back. The degree of *scoliosis* and its direction appears to vary independently of the deformity of the scapula. The classification of the different types of cases is thus made by Horwitz: "1. Simple elevation, no muscle defect or articulation. 2. Elevation with bony, cartilaginous, or fibrous attachment. 3. Elevation with muscle defect."

Diagnosis.—While in general the condition of congenital elevation of the scapula is readily diagnosticated by inspection and palpation, it must be differentiated from certain other conditions—namely, "1. Rachitis. 2. Osteomalacia. 3. Badly united fractures of the scapula. 4. Paralysis. 5. Severe scoliosis. 6. Cervical Pott's disease (in bilateral cases). 7. Empyema. 8. Muscle contractures."—Horwitz.

From the history of the appearance of the deformity in early infancy, it is usually possible to differentiate congenital elevation of the scapula from other conditions. An important point in the diagnosis is the recognition, either by palpation or by an X-ray picture of the infantile shape of the bone—namely, that its vertical diameter is diminished, while its horizontal diameter is increased. Further, after *fractures* of the bone, there will have been a history of injury to the shoulder. In the elevation of the scapula caused by *lateral curvature* of the spine, the scapula upon the convex side of the curve will always be elevated. Following *empyema*, the entire side of the thorax will be deformed,

there will be a scar and a history of the preceding disease. When the elevation is due to *paralysis* of muscles which normally hold the scapula down, the condition will usually be evident from ordinary methods of examination. When the disease is bilateral it might possibly be confounded with tuberculosis of the bodies of the vertebræ. The pain accompanying disease of the vertebræ will be absent. In congenital elevation of the scapula there is *limitation in the motion of abduction of the arm.* Such is not the case with disease of the vertebræ. An X-ray examination will often be of value in cases of doubt.

Congenital Dislocation of the Shoulder-joint.—A true congenital dislocation of the shoulder-joint due to imperfect development of the glenoid cavity of the scapula, or of the head of the humerus or both, is one of the rarest of congenital deformities. Even in the few cases reported the actual congenital nature of the dislocation is almost doubtful. (Stimson.) The most complete report of the condition was made in 1847 by R. W. Smith. He observed several cases, but only two appear to have been truly congenital. Both occurred in lunatic women, and upon the bodies of each he was able to perform an autopsy and study the anatomical relations of the parts. One was a double subcoracoid dislocation, the other a double subacromial dislocation. In the first case the glenoid cavity seemed almost absent from its normal situation, but a cavity, similar to the normal one, had been developed upon the anterior or costal surface of the scapula. The head of the humerus was abnormal in size and shape. The remainder of the articulation was very nearly perfect. Upon the opposite side in this case the deformity was very similar. In his second case, a double congenital subacromial dislocation, a glenoid cavity had been developed upon the external surface of the neck of the scapula, with which the head of the humerus articulated. The shoulder of the opposite side presented similar peculiarities.

By far the largest number of cases of supposed congenital dislocations are due to injury to the shoulder during labor, or possibly during intra-uterine life, or are due to paralyses of the muscles of the upper extremity, produced by injuries to the brachial plexus during delivery, either by the pressure of the blade of the obstetric forceps, or by improper traction upon the arm, or lateral flexion of the neck.

Dislocations Produced During Delivery.—They are usually dorsal dislocations, either subacromial or subspinous. Stimson considers that these dislocations are probably all of them traumatic, and says: "My reasons for thinking this group probably traumatic are that the limitations of motion closely resemble those of the same traumatic dislocation in adults, and that the bones, as shown in a few operations and in the radiographs of three of my cases, differ from the normal only in being smaller." [1] In a certain proportion of these cases the deformity is not recognized at birth and in some the advice of a surgeon has not been sought until the children were several years old. In

[1] Stimson, "Fractures and Dislocations," p. 612, Lea Brothers, 1907.

most of the cases attention has been directed to the shoulder-joint on account of the fact that the child did not move the affected arm, or did not move it freely.

The signs and symptoms observed have been as follows: The motion of the shoulder-joint is limited in all directions. The head of the bone is palpable and usually visible behind the acromion. The motions of outward rotation and adduction are very much restricted. The elbow is held a little forward and rotated inward. In these cases, as in all displacements of bone, no method of diagnosis is so accurate as the taking and viewing of a pair of stereoscopic pictures of the part. In a number of the reported cases the dislocation has been discovered soon after birth, since attention has been directed to the shoulder from the fact that the child cried whenever the upper extremity was moved.

Paralytic Dislocations.—In another group of cases, sometimes spoken of as congenital, the displacement of the bone, which may be complete or partial, is due to injuries of the brachial plexus during delivery and to the resulting paralysis of the muscles about the shoulder, such that the humerus loses its normal support and its head is held in the glenoid cavity only by atmospheric pressure. The injury is produced by strong lateral flexion of the neck or by downward traction upon the arm, or by both. From the weight of the limb the ligaments of the shoulder-joint become relaxed, until finally the head of the bone may be slipped forward or backward out of the glenoid cavity by slight degrees of violence. The paralysis is known as birth paralysis, or as obstetrical palsy, or by the name of the two men who independently described it, Erb-Duchenne. In both of the last two groups the functional usefulness of the entire upper extremity is often seriously impaired, and in many cases the bones do not develop as perfectly as upon the sound side, so that the whole extremity may remain throughout life smaller and shorter than its fellow. The diagnosis of birth palsies is described under injuries of the brachial plexus. The resulting dislocation is nearly always backward, though it may be downward and forward. The muscles paralyzed are usually the deltoid, the spinati, the biceps, and the brachialis anticus, though other groups of muscles may also be paralyzed, if nerve roots other than the fifth and sixth cervical are injured. In general, the diagnosis of these conditions is plain from the history and upon inspection and palpation. In cases of doubt the electrical reactions of the muscles should be tested. (See also Injuries of the Brachial Plexus.)

INJURIES OF THE SHOULDER AND SHOULDER REGION

Injuries of the skin and subcutaneous tissues of the shoulder are common as the result of blows and falls. Others are due to greater degrees of violence, such as run-over accidents or accidents caused by moving machinery. Whether subcutaneous or open wounds, the diagnosis of these injuries presents no special difficulty. The muscles surrounding the shoulder-joint are occasionally ruptured by muscular effort or by sudden forcible traction upon the limb. Such ruptures affect especially the deltoid muscle and the pectoralis major; occa-

sionally the long tendon of the biceps. In the case of the two former muscles the rupture is rarely complete. The injuries are to be recognized by pain and tenderness, sometimes by notable swelling from hemorrhage, and by more or less complete loss of function of the injured muscles. In case the rupture involves a considerable portion of the muscle, a groove or hiatus may be palpable in the muscular belly. If the deltoid muscle is ruptured close to its insertion in the humerus, the upper portion of the muscle would form a considerable tumor, while a corresponding hollow would be observable below. Dislocation of the long tendon of the biceps has been described as the result of muscular violence. The condition has never been verified by actual dissection. The symptoms of rupture of the long tendon of the biceps will be spoken of under Injuries of the Arm.

Some of the cases diagnosticated as myalgia, or muscular rheumatism about the shoulder-joint, in which the chief symptom is pain when the muscles are called into action, or which may be spontaneous pain of a dull, aching character, are unquestionably due to partial ruptures of tendinous or muscular fibers, due to violent muscular efforts. The muscles chiefly affected are the trapezius and the deltoid. The condition may follow blows or falls upon the shoulder or a single sudden violent muscular effort; or, in other cases, it may be due to prolonged and very severe muscular effort of a character to which the individual is not accustomed. Such muscular pain may not be recovered from for several months.

Injuries of the Blood-vessels of the Axilla.—Injuries of the axillary artery and vein may be open or subcutaneous wounds. A considerable proportion of these injuries are complicated by injuries of the contents of the thorax, of the great vessels at the root of the neck, of the thoracic duct, of the nerves of the brachial plexus, or by dislocations and fractures of the humerus.

The open wounds of the axillary vessels may be incised, punctured, or gunshot wounds. The incised wounds are produced by cuts and stabs with knives, daggers, bayonets, swords, and the like. In such cases the wound may divide or open the axillary artery, or the vein, or both. In other cases not the main arterial trunk, but one of its branches, the subscapular or the circumflex artery, for example, may be divided. Incised or stab wounds which divide or widely open the axillary artery or vein are attended by such profuse bleeding that, unless instant surgical aid is at hand, the individual bleeds to death in a few moments. If direct pressure can be made upon the bleeding point until suitable arrangements are completed for the formal enlargement of the wound and ligation of the bleeding vessels, the patient's life may be saved.

If the wound of the artery is small, a mere lateral puncture, for example, or if one of the arterial branches merely is divided, and if, in addition, the wound in the soft parts be very narrow, one of two results may follow. The amount of bleeding may be small and may be stopped by the pressure exerted by the tension of the surrounding soft parts. This result will very rarely happen in the axilla, since here the blood has abundant opportunity to diffuse

itself widely through the connective-tissue planes. I mention such a possibility here because spontaneous cessation of bleeding has been observed after a lateral puncture of the axillary artery by a small-calibered rifle bullet. (MacCormac.) The second result is that an arterial hematoma will be formed in the axilla of variable size. The external bleeding in these cases may be trifling. This condition will be spoken of more at length under Subcutaneous Injuries of the Axillary Vessels.

Wounds of both artery and vein will, if both trunks are divided or widely opened, and if the external wound be of considerable size, end promptly in death from hemorrhage. Punctured wounds of both artery and vein may be followed either by the formation of an arterial hematoma of greater or less size, or by the subsequent formation of an arterio-venous aneurism. This condition has been observed in recent wars a number of times as the result of gunshot wounds produced by military rifle bullets. The diagnosis of these several conditions presents, as a rule, no difficulties. Active hemorrhage is readily recognized by any one. In the event of the formation of a hematoma of considerable size in the axilla a fluctuating swelling will be slowly or rapidly formed, sometimes beneath the deltoid, in other cases beneath the pectoralis major muscle, in exceptional cases posteriorly—that is to say, partly beneath the deltoid and partly projecting beyond the posterior border of that muscle. The tumor will give the signs of fluctuation. There will, however, be an absence of expansile pulsation, of thrill, though a whirring murmur may or may not be present. In addition, if the axillary artery is completely divided, there will be absence of the radial pulse. The persistence of the pulse at the wrist will indicate either that the main vessel is merely punctured or that the wound is of a branch, not of the main trunk. In addition there will be present, according to the quantity of blood which has escaped into the surrounding tissues, the symptoms, more or less marked, of hemorrhage in general. The symptoms of shock, if present, may be dependent upon associated injuries, upon fear, or such symptoms may be very marked, though the injury consist of a division of the artery merely.

Open Wounds of the Shoulder and Axilla Resulting from Blunt Violence.—Under this head I refer to such injuries as are produced when the shoulder is run over by the wheel of a heavy vehicle, a trolley car, a locomotive, or the like, or is crushed between the floor and a moving elevator, or by the fall of a heavy beam. Injuries of this character are rather common in the City of New York and are often seen in the larger hospitals, where patients with various forms of serious accidental wounds are received daily. The injury to the vessels in these cases is often merely a part of a compound comminuted fracture of the upper part of the humerus, with extensive lacerations of the soft parts. In some of these cases the injury to the axillary vessels is evident by inspection of the wound. The vessels may be completely divided, or crushed without solution of their continuity, or merely contused. In the first two groups of cases mentioned the diagnosis presents no difficulties. The artery will be found pul-

sating down to the point where it is crushed or torn apart. Below that point no pulsation will be found in the limb. As elsewhere stated, these injuries bleed, as a rule, but little. If the artery is merely contused, there may be a rupture of the intima and of the muscular coat. The *radial pulse may be present* in these cases for some hours, only to *disappear* later, when *thrombosis* of the vessel has occurred. The associated injuries of the muscles, the bone, together with the extensive stripping up of the skin and laceration of the subcutaneous tissues, are conditions very unfavorable for the reëstablishment of a collateral circulation, and gangrene of the extremity, frequently associated with mixed pyogenic and saprophytic infection, is to be expected in a certain proportion of these cases. Amputation will frequently be necessary in such cases. (See Diseases of Wounds Caused by the Pus-producing Bacteria, also Gangrene, vol. i.) Not only in the cases of injury to the axillary vessels from blunt violence, as just described, are the conditions for the reëstablishment of a collateral circulation unfavorable, but also in those cases of stab and puncture wounds followed by the formation of an arterial hematoma, since in the latter the pressure of the effused blood caused by the hematoma and also by the widely diffused infiltration of the surrounding tissues causes such pressure upon the smaller blood-vessels of the part that gangrene of the limb is a not infrequent sequence. In these also the conditions are favorable for infection, and unless amputation be done or the wounded artery be ligated, as may seem best in the individual case, secondary hemorrhage is a very probable danger. In the cases which survive under conservative treatment, with the production of a large arterial hematoma, or the formation after weeks or months of an aneurism (in case contusion merely of the artery has occurred, with weakening of its coats), the tendency is for the skin to be perforated and for the aneurism to burst, with fatal results.

The prognosis, then, of incised, punctured, and contused and lacerated wounds of the axillary artery is not very favorable. The older statistics for these injuries are as follows: Pirogoff gave the general mortality as 68.1 per cent. Billroth found the mortality of secondary hemorrhages 81.2 per cent. Thormann collected seventeen stab or puncture wounds of the axillary vessels with a mortality of 42.2 per cent.

Open Wounds of the Axillary Vein.—Wounds in which the axillary vein alone is opened are very rare as the result of accident. The diagnosis of venous hemorrhage would not be difficult and the situation of the wound would point to its probable source. Surgical operations upon the axilla, notably for the removal of the carcinomatous lymph nodes, are rarely complicated by accidental wounding of the vein. I saw one such case, where the axillary vein was torn open by the teeth of a sharp retractor. The axillary vein was tied above and below the point of wounding. The patient suffered from diabetes. Gangrene of the arm followed and was treated by amputation at the shoulder-joint. The patient did not survive.

It occasionally happens in cases of malignant disease that the axillary vein is adherent to or involved in the growth and is in part extirpated intentionally

by the surgeon. The resulting disturbances of circulation are not, as a rule, serious if suitable treatment—i. e., suspension of the limb, etc.—is employed. Wounds of the axillary vein are attended by the same danger which obtains in wounds of veins at the root of the neck—namely, the aspiration of air. As elsewhere stated, if the amount of air is small, the symptoms may be slight or absent. If large, death may occur in a few moments.

Gunshot Wounds Involving the Axillary Artery and Vein.—As stated when describing the effects of gunshot wounds in general, the lesions produced by bullets vary greatly with their size and also with the velocity of their flight. Soft-lead pistol bullets and soft-lead rifle bullets, traveling at low velocities, often fail to puncture the walls of vessels. The vessel is often pushed aside, or merely contused, or if the vessel is divided by these missiles, the likelihood of violent hemorrhage is not as great as though the artery were cleanly cut, as by a knife. Wounds by soft-lead rifle bullets at close or moderate range will, however, frequently be attended by serious or fatal bleeding. If the bullet is of considerable size, there will often be an associated comminuted fracture of the humerus, and if the bullet fails to wound the artery, a sharp bone fragment may do so. Modern military bullets will usually miss the vessels altogether, or, if they are wounded, a clean perforation or a lateral wound in the wall of the artery results. Recent wars have shown that these wounds either bleed the patient to death before aid can be given, or else that they bleed but little. In some cases even the soft parts may so plug the wound in the arterial wall that the hemorrhage is very slight. Cases have been observed in which, after a lateral wound, the artery has healed with a diminution of its caliber. If both artery and vein are wounded, an arteriovenous aneurism may form, giving characteristic signs and symptoms. In the head of the humerus, when traveling at high velocity, the small-calibered bullets frequently make clean perforations through the head of the bone without comminution. If the harder surgical neck is struck, fissures and comminution are more common, and in these cases a bone fragment may injure the vessels. In the cases where external arterial bleeding occurs, or where an arterial hematoma is formed, the diagnosis of injury to a large arterial trunk will be self-evident. Here, as elsewhere, the wounds made by small-calibered rifle bullets are much less apt to be infected than those produced by soft-lead bullets. Hence the dangers of sepsis, thrombosis of the vessels, secondary hemorrhage, and gangrene of the extremity are less apt to occur.

Subcutaneous Injuries of the Axillary Vessels.—Subcutaneous injuries of the axillary vessels may occur as a complication of fractures of the clavicle, of fractures of the upper end of the humerus, rarely as a complication of fractures of the neck of the scapula. The most interesting group of subcutaneous injuries of the axillary vessels are those which have followed dislocations of the shoulder-joint. In some of these the injury has occurred at the time the dislocation was produced. In others it has been produced by the surgeon during efforts at reduction. The injuries thus produced have been attended by a very

high mortality—namely, about seventy per cent. It has not always been possible to determine whether the axillary artery alone, the vein alone, or both artery and vein, or in still other cases merely one of the larger branches of the axillary artery, has been ruptured or torn away from the parent trunk. In several instances, however, it has been determined that the circumflex artery or the subscapular has been the vessel injured. The accident has occurred both in young persons and in the elderly whose arteries were the seat of atheromatous degeneration. The mechanism of the production of the injury has varied somewhat in different cases. In some the artery has been rutured as the immediate result of violent traction upon the upper extremity, such as was formrly used before the more modern methods of reduction were practiced. In some the accident has followed strong abduction of the arm, or circumduction, or, as in a case quoted by L. A. Stimson,[1] "that of a man sixty-eight years old; subcoracoid dislocation six weeks old. Ether; manipulation to rupture adhesions; Kocher's method tried twice, then heel in the axilla. Then arm carried forcibly across the body, the head slipping to the outer side of the glenoid fossa; finally, traction in abduction succeeded. Died five hours later. Autopsy showed rupture of the axillary vein and of the short head of the biceps; capsule entirely torn from the humerus; third, fourth, and fifth ribs fractured in the axillary line." The most complete records of the injury to the axillary vessels are those collected by Stimson. Up to May, 1907, only fifty-six cases of injury to the larger vessels of the axilla as the result of dislocation, or during the reduction of a dislocation of the shoulder, had been reported. The mechanism of the injury has in most cases been that the vessels already stretched across the head of the displaced bone are still further put upon the stretch by the motions of the head made by the surgeon in attempting reduction. In this regard Stimson says:[2]

> In some the injury was evidently caused by excessive traction; in others by faulty manipulations, such as extreme abduction or elevation of the arm, rotation, and circumduction; in others again apparently by direct compression of the vessel against the underlying bone, as by the booted heel in the axilla, or possibly by the thumbs.

Leaving aside the earlier cases in which faulty methods no longer in use were employed and those old dislocations in which the relations and connections had been permanently changed by fibrous or bony tissue of new formation, it becomes evident that in dislocation of the shoulder the accident is most to be apprehended when the elbow is raised in abduction to the height of the shoulder, or is carried, as in Callender's and Weir's cases, across the chest and face in a wide movement of circumduction; and for this reason, that in these movements the dislocated head of the bone is turned downward into the axilla and the vessels which lie upon its inner side are pressed down before it and forcibly put upon the stretch, while those branches which run almost directly outward, the subscapular and circumflex, and are fixed to the tissues amid which they branch, are directly and forcibly elongated. Although in dislocation inward the limb is shortened by being abducted, yet the

[1] *Loc. cit.*, p. 446.

[2] *Ibid.*, p. 454.

artery is not thereby relaxed, but, on the contrary, is still further stretched around the head of the bone.

In more than half the cases recorded by Stimson the dislocation was of less than three weeks' standing. In reference to the occurrence of the accident it should be borne in mind that in those individuals whose arteries are brittle from old age, or other cause, injury to the vessels is likely to be produced by degrees of violence much slighter than would be necessary in young persons whose arteries were normally elastic, and that the dangers are still further increased when the dislocation is old and when the structures of the axilla are bound together by scar tissue. In thirty-three of the collected cases death, or amputation of the arm, permitted the study of the lesion to the vessels. In some the artery was found totally or partially ruptured, and usually at such a point as to indicate that the injury had been produced by the pressure of the head of the humerus. In other cases the artery was contused merely, with rupture of its inner coats, and the subsequent formation of an aneurism. In some the injury of the artery was followed by rupture after a number of days, and in others an aneurism formed after weeks.

In five cases only a small (one sixth of an inch) oval opening was found on the anterior wall of the artery, and was thought to have been produced by the tearing off of a branch, the subscapular or circumflex.[1]

Symptoms.—The symptoms following injuries to the artery as the result of the accident or of efforts at reduction have presented two different types. In the first and most common the accident, or the manipulations, were followed at once by an arterial hematoma in the axilla, as already described under Punctured Wounds of the Vessel. In many of these the general symptoms of shock and hemorrhage were marked, from which a number of the patients speedily died. Eight only recovered without operation. In the second group of cases there appeared, at a time after the injury varying from days to weeks, a tumor over the vessel presenting the signs of aneurism. A marked tendency was shown in these cases toward a rapid increase in size and final rupture if not treated surgically. The same diagnostic data would apply in these subcutaneous injuries of the axillary vessels as were given under the head of Punctured Wounds. The rapid formation of a fluctuating tumor in the axilla would point to the injury of a blood-vessel. If the radial pulse persisted, it would be probable that an arterial branch, rather than the main trunk, was ruptured. If the radial pulse disappeared after hours or days, it would point to thrombosis of the artery; and such an occurrence has been followed by gangrene of the whole or a portion of the limb in a number of instances. In the cases followed by the later development of an aneurismal tumor the signs and symptoms would be those of aneurism, as already described. (See Aneurism.)

[1] Stimson, *loc. cit.*, p. 453.

Prognosis.—In the cases collected by Stimson the results were as follows: There were 16 recoveries and 32 deaths. In 1 case the result was not known. In 21 cases no operation was done. Of these, 6 recovered and 15 died. In 6 cases an icision was made in the axilla and the artery tied above and below the point of rupture; all the cases died. In 4 amputation was done at the shoulder-joint; 3 died and 1 recovered. In 16 cases the subclavian was tied; 6 recovered, 8 died, and in 2 the result was unknown.[1] The general inference to be drawn is that in elderly people, with unreduced dislocations of the shoulder, the risk of injury to the vessels is by no means slight, and that, if reduction is attempted, the manipulations previously recorded as dangerous should be avoided, and, further, that attempts at reduction should neither be violent nor prolonged. These cautions are increased in force when we consider the very large mortality which has followed injury to the vessels in these cases, and, further, that a dislocated shoulder may still leave the individual with a very useful limb.

INJURIES OF THE NERVES OF THE UPPER EXTREMITY

The nerve trunks forming the brachial plexus are derived from the anterior primary divisions of the fifth, sixth, seventh, and eighth cervical nerves, together with the first dorsal, in whole or in part, and with a small portion of the fourth cervical. These cords unite and subdivide, ending below in the several nerves supplying the arm, forearm, and hand. In injuries of the brachial plexus the motor paralyses are much more prominent and more important than the sensory symptoms. Thus, the fifth, sixth, and seventh cervical nerves containing the fibers of cutaneous sensibility, derived from the corresponding posterior roots, may be divided without producing sensory disturbances recognizable by any means of examination. The following motor distribution of the brachial plexus is that adopted by Sherren:[2]

Fifth Cervical.—Deltoid, biceps, brachialis anticus, supinators, rhomboids, usually the spinati, occasionally the radial extensors of the wrist, rarely the pronator radii teres.

Sixth Cervical.—Pronators, radial extensors of the wrist, clavicular portion of pectoralis major, serratus magnus.

Seventh Cervical.—Triceps, extensor carpi ulnaris, extensors of fingers, pectoralis major.

Eighth Cervical.—Flexors of wrist, flexors of fingers.

First Dorsal.—Intrinsic muscles of hand.

The most varied kinds of violence may injure the cords of the brachial plexus, among them stab and gunshot wounds, the latter being fairly common in time of war. Much more frequent, however, are the subcutaneous injuries.

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[1] L. A. Stimson, *loc. cit.*, p. 456.

[2] "Injuries of Nerves and their Treatment," James Sherren, p. 186, William Wood & Co., New York.

The cords of the plexus may be injured above and below the clavicle. The subcutaneous injuries above the clavicle occur most often as the result of indirect violence. They may be produced by crushing injuries of the neck above the clavicle, by fractures of the clavicle, but in a larger proportion of cases *they are traction injuries*, as from violent lateral flexion of the head or violent traction upon the arm. In the latter group, if the traction is exerted in a downward direction, the upper cords of the plexus are more apt to be injured, fifth and sixth cervical. If the traction is exerted in an upward direction the lower cords are more apt to suffer. The most common type of injury is that the fifth and sixth cervical nerves are stretched or torn. The type of paralysis produced is known as the "Erb-Duchenne paralysis." The most frequent cause of injuries to the plexus below the clavicle is pressure by the head of the humerus in dislocations of the shoulder, or efforts at reduction of such dislocations. They may, however, also occur from falls upon the shoulder, or upon the hand or elbow. In the Erb-Duchenne type (supraclavicular) the muscles most commonly paralyzed are the deltoid, the biceps, the brachialis anticus, and the supinator longus. The supra- and infraspinatus may be involved in certain cases. As will be noted, all these muscles receive their supply from the fifth and sixth cervical nerves. The last two muscles, however, are partly supplied by the fourth cervical, but this may easily be injured when the fifth cervical is affected. When the injuries are extensive and severe the resulting disability is very serious. The arm cannot be raised from the side on account of paralysis of the deltoid, the forearm cannot be flexed nor strongly supinated. The muscles undergo an early atrophy. There is developed in bad cases the electrical reaction of degeneration. Fibrillary twitchings of the affected muscles are not uncommon. The sensory symptoms are not marked. There may be numbness and tingling of the shoulder and in the radial portion of the forearm and hand. The whole upper extremity hangs helpless at the patient's side. The shoulder droops on account of atrophy of the deltoid. It is in this group of cases especially that dislocation of the shoulder may occur, after a time, complete or partial, from traction upon the relaxation of the ligaments of the shoulder-joint, due to lack of support by the muscles. When these injuries occur at birth the development of the upper extremity is seriously interfered with and the prognosis as to restoration of function is not good.

The *diagnosis* in infants and adults usually presents no difficulties. When the paralysis occurs as the result of traction upon the arm during delivery, or of abduction of the head, or from the pressure of the fingers of the obstetrician, or of the blades of the forceps directly upon the nerve trunks, it will be noticed that the child does not move its arm normally, and that passive movements are painful. It is not easy to take the electrical reactions of the muscles of infants; it may, however, be done, if necessary for a diagnosis, under general anesthesia. The Erb-Duchenne type of paralysis is known as the upper-arm type and is the most common form following injuries from indirect violence to the brachial plexus. A second and much rarer form is known as the lower-arm

type of paralysis, or, from the man who first thoroughly studied it, as Klumpke's, or the lower-arm type of brachial-plexus paralysis. In its pure form this is a much rarer condition than the upper-arm type. When observed alone, it consists of a paralysis of the first dorsal root. There is paralysis of the small muscles of the hand, together with loss of the cilio-spinal reflex, contraction of the pupil of the eye, sinking in of the eyeball, and drooping of the upper lid. There are no vasomotor disturbances.

This form of paralysis follows sudden violent stretching of the lower cords of the plexus, such as might be produced when an individual, to save himself from falling, grasped some object with his hand above his head, so that the weight of the trunk fell upon one arm, or other similar injury, as, for example, during delivery when the breech presents and the arms are extended above the head. In some cases of severe traction upon the brachial plexus much more extensive paralyses may be present at first. After a time, when the patient has partly recovered, there will be left behind an upper-arm paralysis or a lower-arm paralysis, which is permanent, according to whether the upper or lower cords of the plexus were more severely injured in the first instance.

Post-anesthetic Paralysis.—The nerves of the upper arm may be injured during anesthesia in one of two ways. When the arms are raised high above the head and permitted to lie in that position, traction upon the nerves and pressure by the head of the humerus on the brachial plexus will produce a paralysis of the upper-arm type. In other cases where the arm is permitted to hang over the edge of the table, pressure will be made upon the individual cords of the plexus in the upper arm. These latter will be spoken of under Injuries of the Individual Nerves of the Arm. In general, neither of these forms of paralysis is very serious. The patients usually recover completely in weeks or months. I have seen one case in which the paralysis lasted nearly a year.

Injuries to the Nerves Produced by the Presence of a Cervical Rib.—In a small percentage only of those individuals possessing a cervical rib, pressure upon the brachial plexus may cause certain nervous disturbances. The symptoms do not, as a rule, develop until adult life. When present they consist of slight weakness of the muscles of the extremity, which may or may not be accompanied by partial atrophy of the muscles, so that the affected extremity is not so well developed as its fellow. In addition, there may be pain of a neuralgic character referred to the inner side of the arm, forearm, and ulnar portion of the hand. Usually these pains are more marked after the individual has undergone severe or unusual muscular exercise. In the more marked cases the intrinsic muscles of the hand may undergo a considerable degree of atrophy. The presence of a cervical rib should be thought of when a patient comes complaining of such symptoms as above related, without any apparent cause. The diagnosis of cervical rib can usually be made by palpation, or, if this fails, it can be made with certainty by means of the X-rays.

Injuries to the Brachial Plexus Complicating Fractures of the Clavicle.—The brachial plexus is very rarely injured as the result of fractures of the clavicle.

In most of the cases which have been observed it seems probable that the injury to the plexus was caused by the same violence which fractured the clavicle, but not to direct injury of the cords of the plexus by the fragments of the bone itself. In a few cases the symptoms have occurred not immediately after the accident, but only later, and have been accounted for by the pressure of callus

FIG. 41.—INJURY TO THE BRACHIAL PLEXUS FROM FRACTURE OF THE CLAVICLE. Paralysis of all the nerves of the upper extremity. (After Bailey.)

formation, and in a few, pressure upon the cords of the plexus has been produced by the introduction of a large, firm pad into the axilla. In some of the recorded cases the spinati have been paralyzed, indicating that the injury to the plexus was above the clavicle and that, therefore, the bone fragments had nothing to do with its production.

Incised and Stab Wounds of the Brachial Plexus.—Incised and stab wounds which injure the cords of the plexus, without at the same time wounding the large blood-vessels of the part, are quite rare, a few only having been recorded. Injuries of the plexus as a result of gunshot wounds are sufficiently common. If the bullet simply punctures one of the cords, the symptoms will be localized in its distribution. If, on the other hand, the gunshot wound is complicated by extensive fractures of the scapula or of the head of the humerus, the bone fragments may tear one or several of the cords of the plexus and the paralyses following such injuries will, therefore, vary considerably in extent and distribution.

Injuries to the Brachial Plexus Complicating Dislocations of the Shoulder-joint.—Injuries to the brachial plexus may be caused by the same violence which

produced the dislocation; or may result from pressure by the head of the bone upon the cords of the plexus in unreduced dislocations; or may be inflicted during the efforts at reduction. During the period when rough and very forcible methods were used in reducing dislocations of the shoulder-joint, especially the method of traction, which was sometimes carried to the extent of pulling upon the arm by four, six, eight, or more persons, complete rupture of the cords of the brachial plexus were sometimes produced. It is probable that in some of these cases the nerve trunks were actually torn away from their attachment to the spinal cord. Such injuries were followed by death in some cases. In others by total paralysis of the upper extremity with subsequent atrophy of the limb. In a certain proportion of cases the dislocation itself, or sometimes the efforts at reduction, have resulted in serious injury to the circumflex nerve, causing paralysis of the deltoid. In some of the cases subjected to operation or to autopsy the nerve has been found completely ruptured, or extensive hemorrhages have been found within its sheath. Subcoracoid dislocations are more apt to be followed by injuries of the plexus than others. In a good many cases the symptoms of pain and paralysis disappear at once, or soon after the reduction, showing that they had been caused by the pressure of the head of the dislocated bone upon the cords of the plexus. In other cases the injuries to the nerve trunks have been permanent, either as the result of the pressure of the head of the bone, usually upon the inner cord of the plexus, very rarely upon the outer cord. The paralysis caused by injuries of the inner cord consists of paralysis of the muscles supplied by the ulnar nerve and of the intrinsic muscles of the hand supplied by the median nerve. There are, in addition, disturbances of sensation on the ulnar surface of the forearm and in the ulnar distribution in the hand. The paralysis of motion and of sensation will be more or less complete, according to the gravity of the injury to the nerve trunks. They are usually wholly or partly recovered from. The posterior cord of the brachial plexus is very rarely wounded alone. Its injury has been observed after dislocations of the humerus. The symptoms produced are those of paralysis of the musculo-spiral nerve and of the circumflex. They are described in detail under Injuries of the Musculo-spiral Nerve. The outer cord of the brachial plexus is occasionally injured in dislocations of the shoulder and fractures or other injuries in the vicinity of the shoulder-joint. The symptoms produced are paralysis of the biceps, the coraco-brachialis, and of the muscles supplied by the median nerve, except the small muscles of the hand.[1] There is disturbance of sensibility on the outer surface of the forearm.

Injuries of the Entire Plexus.—The entire brachial plexus may be divided by a cutting instrument or by a projectile. Much more commonly, however, such injuries are the effects of blunt violence applied to the head or to the side of the neck, or sometimes to the shoulder. As already stated, a similar injury may be produced by violent traction upon the arm.

[1] Sherren, *loc. cit.*, p. 201.

Symptoms of Destruction of the Brachial Plexus.—The *symptoms* produced by complete destruction of the conducting power of the brachial plexus consist of total paralysis of motion in the arm and forearm. If the injury is well above the clavicle, the supra- and infraspinatus, the pectoralis major and minor are paralyzed. There is often also some paralysis of the cervical sympathetic; frequently the rhomboid muscles and the serratus magnus escape. The sensory loss as described by Sherren [1] is as follows:

Epicritic and protopathic sensibility are lost over the whole of the forearm and hand, and over the outer surface of the arm in its lower two thirds, the area overlapping onto the anterior and posterior surfaces. The sensitive area on the point of the shoulder gives the full supply of the descending branches of the cervical plexus, that on the inner side of the arm, the portion of skin supplied by the intercosto-humeral and small internal cutaneous nerves. Deep touch is lost over the forearm.

Prognosis.—The prognosis of these injuries, if severe, is very unfavorable. A number of instances are reported where attempts to unite the divided nerve trunks, or to liberate them from the pressure of scar tissue, have failed. The nerves have been found to run into a mass of cicatricial tissue such that it was impossible to separate the several trunks in such a manner as to render their isolation and suture practicable. (McBurney, Bolton, Hartley, Kammerer.) In a general way it may be said that the prognosis of this type of injury is particularly unfavorable not only on account of the manner of its causation, but also on account of the fact that the nerve cords are in many instances totally severed, and, further, that, even if successfully sutured, a very long time must elapse before regeneration to the distant muscles of the forearm and hand can occur. During this long period it is infrequent that such care by message, electrical stimulation, passive motion, and attention to the mobility and position of the several joints can be carried out so thoroughly as to prevent stiffness of joints, shortening of groups of muscles, and permanent deformities.

Injuries to Individual Nerves in the Vicinity of the Shoulder

The Posterior Thoracic Nerve.—The posterior thoracic nerve, or nerve of Bell, supplies the serratus magnus muscle. Injury to this nerve may occur as the result of violent muscular effort and has been noted after labor.[2] It sometimes results from severe pressure above the clavicle. As the result of accidental external violence, the nerve is rarely injured alone. The nerves going to the lower portion of the trapezius muscle are also affected in the majority of cases. A rather frequent cause of division of the posterior thoracic nerve is its accidental severance during the operative removal of carcinoma of the breast, while cleaning out the axilla. It is, therefore, important in making this dis-

[1] *Loc. cit.*, p. 194.

[2] Bailey, *loc. cit.*, p. 266.

section to identify and clean the nerve so that it may not be accidentally cut. The symptom produced by injuries of the nerve are paralysis of the serratus magnus muscle. This causes the scapula to flare away from the ribs more than is normal; its inferior angle also approaches nearer to the middle line of the back. The flaring is more noticeable when the individual moves the lower arm forward. Abduction of the arm above the horizontal is usually impossible. Forward pushing movements are feeble, or cannot be made. In cases where the nerve is merely contused the prognosis as to return of function is fairly good. If it is actually divided in the course of a surgical operation no return of function is likely to take place.

The Circumflex Nerve.—Division of the circumflex nerve causes paralysis and subsequent atrophy of the deltoid muscle. As elsewhere stated, the shoulder is flattened, the acromion process is prominent, the power of abducting the arm is lost or seriously weakened. If the infra- and supraspinati are also divided,

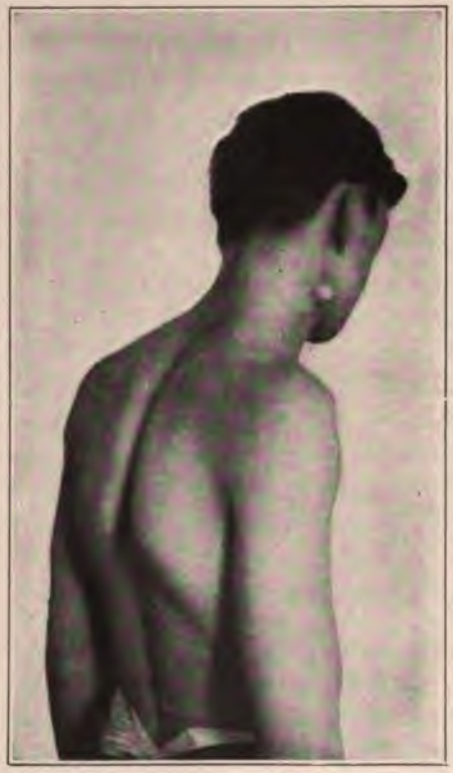

FIG. 42.—ATROPHY OF THE DELTOID AND DROOPING OF THE SHOULDER DUE TO PARALYSIS OF THE CIRCUMFLEX NERVE. (Bailey.)

FIG. 43.—PARALYSIS OF BOTH CIRCUMFLEX NERVES FROM ANTERIOR POLIOMYELITIS TWO YEARS BEFORE. (New York Hospital collection, service of Dr. Frank Hartley.)

there may be a dropping of the head of the humerus from the glenoid cavity, with the production of a paralytic dislocation, as elsewhere described. The nerve is most often injured as the result of dislocations of the shoulder; in

fractures of the surgical neck of the humerus; or in fractures of the scapula; or as the result of chronic pressure in the axilla from a crutch. The nerve is more apt to be injured in subglenoid than in subcoracoid dislocations, but has been observed in both. If the paralysis is permanent, the other muscles attached to the vicinity of the head of the humerus—namely, the clavicular portion of the pectoralis major and the spinati—still enable the individual to abduct the arm to some extent. (Duchenne.) In total division of the circumflex nerve there is an elliptical area of loss of sensibility on the outer aspect of the upper arm, extending from the acromion downward as far as the insertion of the deltoid. The loss of sensibility to light touch is a little more extensive than the loss to pain.[1]

The Suprascapular Nerve.—Cases of isolated injury of this nerve are extremely rare. They have been produced by severe pressure in the supraclavicular region, occasionally by falls upon the hand. The symptoms produced are not very marked. The muscles above and below the spine of the scapula, supra- and infraspinatus, respectively, undergo atrophy so that the spine of the scapula appears more prominent. The motion of outward rotation of the upper arm is diminished in power, but is still carried out by the posterior fibers of the deltoid and teres minor. If these muscles are also paralyzed (fifth cervical), the power of outward rotation is lost.[2]

The Musculo-cutaneous Nerve.—Isolated injuries of this nerve are rare. Its complete division causes paralysis of the biceps, the coraco-brachialis, and partial paralysis of the brachialis anticus. Paralysis of the biceps causes enfeeblement of the power of flexing the elbow-joint, together with the loss of powerful supination. The supinator brevis still permits supination to be made, but not with normal power. The sensory disturbances are chiefly observable as a loss of sensibility to light touch and to pain over the front of the forearm, chiefly upon its ulnar half.

The Musculo-spiral Nerve.—The musculo-spiral nerve is probably more often injured than any other nerve in the body. The injuries are usually subcutaneous, due to pressure or stretching rather than to open wounds; although, of course, the nerve may be divided under special circumstances. I have seen it cut in a case upon which I operated some years ago, of a youth who fell with the outer and posterior aspect of his left upper arm against a moving circular saw. The extensor muscles of the arm were divided obliquely from above downward and outward, and the humerus was cut cleanly in two, causing an oblique fracture. The injuries stopped at this point, sparing the brachial artery and other nerve trunks. All the divided structures were properly sutured, but the patient passed out of observation too soon for me to know whether his musculo-spiral nerve united or not.

One of the most frequent causes of injury to the musculo-spiral nerve is fracture of the shaft of the humerus. The nerve may be crushed or torn at

[1] Sherren, *loc. cit.*, p. 218.

[2] *Ibid.*, p. 215.

the time of the fracture, or may later be involved in callus production, or in some cases included in the surrounding new bone. It is also occasionally wounded in operations for ununited fracture of the humerus.

Every one is familiar with the paralysis of the musculo-spiral which results from falling asleep with the arm hanging over the back of the chair. In a normal individual the discomfort caused by pressure upon the nerve is sufficient to cause him to wake up; but with those who are unconscious from alcohol or other poison such is not the case, and prolonged pressure in this way causes the well-known "Saturday night," or sleeping paralysis. The nerve may also be

FIG. 44.—DROP WRIST FROM PARALYSIS OF THE MUSCULO-SPIRAL NERVE. (After Bailey.)

pressed upon higher up in the axilla by a crutch. The symptoms of musculo-spiral paralysis are paralysis of the extensors of the wrist producing the well-known "wrist drop." (See Fig. 44.) The nerve is very rarely injured high enough to cause paralysis of the triceps muscle. When, however, such is the case, the power of extension in the elbow will be lost, or greatly weakened. Only occasionally is the nerve injured seriously high up in the axilla, as already described under Injuries of the Brachial Plexus. If the injury occurs below the region of the branch to the triceps there will be paralysis of the extensors of the wrist, the fingers, and of the thumb, as well as of the supinators of the forearm. The position of the hand is, as stated, characteristic. When held palm downward the whole hand droops from the wrist. If the paralysis lasts for some time, relaxation of the ligaments upon the dorsum of the wrist causes

a partial luxation of the carpal bones, so that they appear unduly prominent. When the patient tries to extend the wrist he cannot do so. Extension of the fingers at the metacarpo-phalangeal joints is impossible. The extensor muscles of the thumb are paralyzed, the paralysis being most characteristic in that the power of extending the terminal phalanx of the thumb is lost. (See Fig. 44.) If the wrist is supported in extension, the terminal phalanges can be extended and the fingers separated by the interossei.[1] The thumb cannot be abducted. The paralysis of the supinator longus causes pronation of the hand when the patient attempts to flex the wrist. In testing for paralysis of the supinator longus muscle, the patient's forearm is placed with its ulnar border upon a table midway between pronation and supination and the power of the supinator longus is tested by asking the individual to flex the elbow against opposition. The diagnosis of the motor paralysis is usually very easy. If, however, there has been no history of an injury sufficient to account for it, it may be well to remember that the paralysis produced by lead poisoning usually involves both sides of the body, and that, as a rule, the supinator longus and the long extensor of the thumb are either not affected or only partially paralyzed. In severe lead palsies also the muscles show marked degenerative changes when stimulated by the electric current, whereas those cases of traumatism to the musculo-spiral nerve, so slight that the diagnosis could be in doubt, will not be attended by the reaction of degeneration in the muscles. (Bailey.)

Sensory Symptoms.—The sensory symptoms of division of the musculo-spiral nerve are not marked. When the nerve is divided in its lower part no definite disturbances of sensation are recognizable. If, however, it is divided above the point where its external cutaneous branches arise, there will be a loss of sensibility upon the dorsum of the hand. This will involve the sense of light touch and the sense of pain, and will have the following limits: the area will begin below the wrist, its ulnar border will be on a line between the third and fourth fingers, its radial border will involve the integument of the back of the thumb, and its lower border will be formed by a line drawn across the basis of the second and third fingers.[2]

The Median Nerve.—The median nerve is more often injured in the forearm and just above the wrist than in any other situation. The accident happens from incised wounds of the forearm and wrist inflicted by knives, or perhaps most commonly by cuts from broken glass. The nerve may also be injured in fractures of the lower end of the radius and in fractures of the bones of the forearm, occasionally in fractures of the humerus in the vicinity of the elbow-joint. It has several times been *seriously injured during operations for the relief of deformity following fractures of the lower end of the radius.* In this last group of cases the accident has happened when the surgeon operated by a dorsal incision. In some of these cases it is necessary to remove a wedge of

[1] Bailey, *loc. cit.*, p. 273.

[2] Sherren, *loc. cit.*, p. 238.

bone, the base of the wedge being directed toward the palmar surface of the wrist. If the wedge is cut out from the dorsal surface with chisels, the wrist must be placed upon a sand bag in order to afford a suitable solid resistance. During the hammering which follows, the median nerve may be seriously contused, or if the chisel goes through the bone into the palmar surface of the forearm, the nerve may be crushed, or actually divided. At the present time such injuries are avoided by approaching the fracture from the radial side and honeycombing the wedge of bone which it is desired to remove by numerous small drill holes; in this way injury to the median nerve may be avoided. (Lothrop.) The median nerve may be injured by a small punctured wound above the wrist which involves no other important structure, since the nerve in this situation is almost subcutaneous. In fractures of the upper part of the forearm, the anterior interosseus branch of the median may alone be injured.

The symptoms of division of the median nerve are motor and sensory. When the nerve is divided high up in the forearm, there is paralysis of the flexor carpi radialis, the flexor sublimis digitorum, and of the radial half of the flexor profundus digitorum. Thus, flexion of the wrist and fingers is imperfect. From the paralysis of the pronators, the wrist tends to assume a slightly supinated position and the power of pronation is impaired or lost. Owing to the paralysis of the flexor longus pollicis, the terminal phalanx of the thumb cannot be flexed; the index finger can be flexed at its metacarpophalangeal joint, only through the interossei muscles, supplied by the ulnar. The flexor carpi ulnaris and the inner half of the flexor profundus digitorum, as well as all the interossei, are supplied by the ulnar nerve. Hence, when the ulnar remains intact, some flexion of the wrist is still possible; the first phalanges of all the fingers can still be flexed as well as the terminal phalanges of the fourth and fifth fingers. Through the unopposed action of the extensors of the thumb supplied by the posterior interosseus, and of the adductor of the thumb supplied by the ulnar, the thumb remains in the position of extension and adduction and lies nearly in the same plane with the fingers. The muscular branches in the forearm are given off a short distance below the elbow, so that division of the median nerve in the middle of the forearm leaves the muscles of the forearm unaffected. Division of the median nerve at the wrist causes paralysis of the abductor and opponens muscles of the thumb and of the first two lumbricales. It may thus be understood that division of the median nerve just above the wrist produces no very marked or characteristic motor paralysis.

Sensory Symptoms.—After division of the median nerve, deep sensibility, as described under Injuries of the Nerves in General, is preserved throughout. The loss of sensibility to light touch corresponds closely to the distribution of the median nerve as figured in the text-books. It must be borne in mind that if the nerve is divided above the region of its muscular branches, there may be also loss of sensibility to deep pressure. The following boundaries for the

loss of light touch and of sensibility to pain—i. e., to the prick of a pin—are those given by Sherren.[1]

Sensibility to light touch is lost over an area on the palm bounded by a line running through the axis of the ring finger. At the thenar eminence the boundary curves radialward and then runs to the radial edge of the thumbnail; starting again at the ulnar border of the nail, it passes along the free border of the first interosseus space and turns downward opposite the highest fold over the first interphalangeal

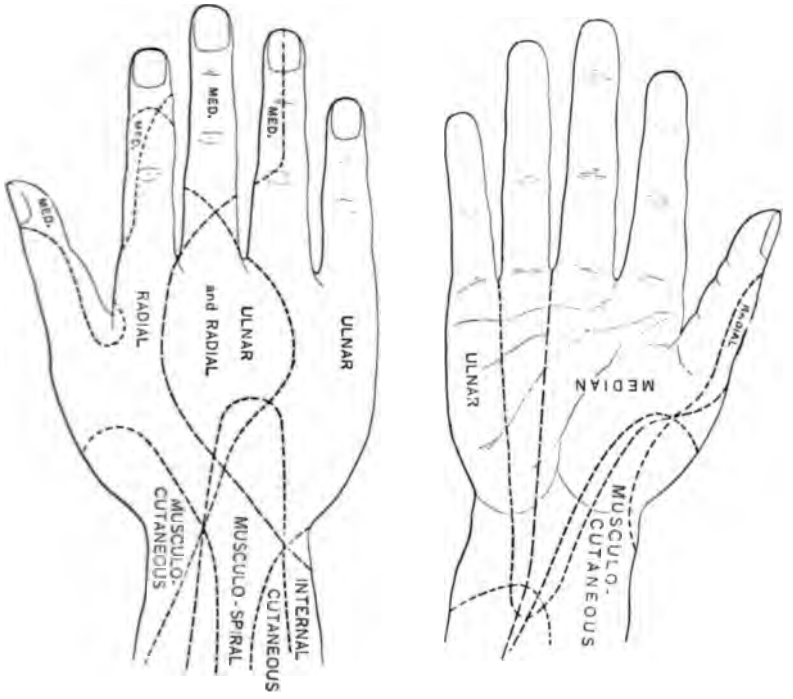

FIG. 45.—DISTRIBUTION OF THE SENSORY NERVES IN THE HAND. (Bailey, after Quain.)

joint. On the dorsum the last two and a half phalanges of the middle and index and half of the last two of the ring finger are insensitive to epicritic stimuli (light touch). Loss of sensibility to pain—that is, to the prick of a pin—varies within wide limits. It may include not only the whole of the terminal two phalanges of index and middle fingers, or be almost as widespread as the sensibility to light touch.

It is always to be borne in mind that if the *tendons are also cut* there will be *loss of sensibility to deep pressure*, which may be as extensive as the loss of sensibility to the prick of a pin.

The Ulnar Nerve.—The ulnar nerve is derived from the eighth cervical, and the first dorsal segments of the spinal cord. It forms a large portion of the

[1] *Loc. cit.*, p. 263.

inner cord of the brachial plexus. In the upper arm the nerve is supe
At the elbow it passes behind the inner condyle of the humerus, between
the ulna. In the upper portion of the forearm the nerve is covered
flexor carpi ulnaris, but near the wrist it again becomes superficial a
therefore, very likely to be injured in this region. On account of its sit
in the lower third of the forearm it is more often cut in accidental w
especially by broken glass, than any other nerve. It may be injured i
part of its course by stab or incised wounds; it is sometimes injur
fractures of the lower end of the humerus involving the internal condy
may be severely stretched in dislocations of the elbow-joint. The effect
duced by injuries to the ulnar nerve vary with the situation of the injur
divided above the region of its motor branches, the following muscles w
paralyzed: the flexor carpi ulnaris, the inner half of the flexor prof
digitorum, all the interossei, the two inner lumbricales, and the adduct

FIG. 46.—BEGINNING MAIN EN GRIFFE. From an injury to the ulnar nerve. (After Bai

the thumb. The interossei flex the first and extend the second and
phalanges of the fingers, so that in ulnar paralysis most of the finer moti
the fingers are abolished. Paralysis of the interossei muscles also cause
of power to adduct and abduct the fingers and to adduct the thumb. The po
of the hand is as follows: the little and ring fingers are hyperextended
metacarpo-phalangeal joints and the index and middle fingers are exten
the same joints. All the fingers are flexed at the interphalangeal joints, a
little finger is also abducted. When the paralysis is complete and has
for some time, the paralyzed muscles undergo atrophy and the unopposed

of the other muscles produces the so-called "claw-hand," or *main en griffe*. The little finger cannot be moved at all. (See Fig. 46.)

Sensory Symptoms.—After division of the ulnar nerve there is loss of sensibility to light touch over the little finger and the ulnar half of the ring finger. The line of anesthesia extends upward, both dorsally and ventrally, through the middle of the fourth finger as far as the wrist. The loss of sensibility to pain is included within the area above mentioned and may correspond with, or be considerably smaller than, it. If the nerve is divided above its motor branches the loss of deep sensibility will closely correspond to the loss of sensibility to pain. If the nerve is divided near the wrist and the tendons are not divided the sensory symptoms will be those already described, in addition to which there will be atrophy of the small muscles of the hand supplied by this nerve.

According to Bailey, the ulnar nerve after injury is peculiarly liable to the occurrence of a traumatic neuritis, which may spread and involve the entire trunk of the nerve. The affection is an extremely painful one, and the inflammation may extend to and involve the functions of other nerves. Bailey [1] relates an instance where a patient developed an ulnar neuritis as the result of a cut on the little finger. "Eventually the nerve became paralyzed for all its functions. The pain was intense and the swollen nerve could be felt as a round cord in the whole of its peripheral course."

Owing to its close proximity to the bones at the elbow-joint the ulnar nerve is peculiarly liable to injury in fractures and dislocations involving the elbow joint. The injury may be immediate or remote. That is to say, the nerve may be torn, contused, or stretched at the time of the accident, or in other cases it may be compressed by callus or by a displaced fragment of bone. In the former group of cases the symptoms of paralysis and irritation of the nerve come on immediately after the accident. A second group of cases is described in which, following an injury to the elbow-joint, a fracture, a dislocation, or a separation of the lower epiphysis of the humerus, the symptoms of the injury subside, but later, sometimes after a period of years, the signs of paralysis with wasting of the muscles and pain referred to the distribution of the nerve appear and cause serious symptoms. In a certain proportion of these cases a thickening of the nerve, a neurofibroma, develops, usually at the point where the nerve passes between the internal condyle of the humerus and the olecranon process of the ulna. The nerve may form a palpable tumor at this point. The diagnosis of the condition is not difficult. There will be a history of a former injury to the elbow-joint and the subsequent development, after a period of years, of the symptoms of paralysis and irritation of the nerve, as described.

The Division of Both Median and Ulnar Nerves.—The division of both median and ulnar nerves produces signs and symptoms equivalent to the sum of the motor and sensory distributions of the two nerves. The injury may occur

[1] Bailey, *loc. cit.*, p. 270.

as the result of incised wounds of the forearm or wrist, and in these cases the wound will, as a rule, be an extensive one, with division of numerous tendons. The paralysis of sensation in these cases will, therefore, involve not only sensibility to light touch, but also to pain, and according to the number of

FIG. 47.—DEFORMITY OF THE HAND CAUSED BY INJURY TO THE MEDIAN AND ULNA NERVES AT THE WRIST. (After Bailey.)

tendons divided, there will be, in addition, an area more or less extensive of loss of deep sensibility.

As already mentioned when describing the injuries of nerves in general, it is highly important when examining incised wounds of the wrist with division of tendons, to test the sensibility of the parts supplied by the median and ulnar nerves in order to discover whether one or both of them has been injured, and if so, whether their division is complete or partial. This should be done before the operative procedures are commenced for reunion of the divided tendons. I have known several instances where surgeons have sutured the tendons and closed the wounds and have entirely forgotten to look for the injuries of the nerves, to their chagrin, when, after the operation was over, it was discovered that the patient had suffered a division of either the median or ulnar nerve, or of both.

FRACTURE OF THE CLAVICLE

The clavicle is fractured very frequently at all ages. Its relative frequency as compared with fractures of other bones varies in the statistics of different writers from 10 per cent, Malgaigne, to 18.7 per cent, Pitha. In general it may be said that fractures of the clavicle probably constitute about 15 per cent of all fractures. It is particularly frequent in children of both sexes, and among these, as was pointed out by Krönlein, it takes the place of dislocations of the shoulder in adults. That is to say, dislocation of the shoulder in an adult by

direct violence is the equivalent of a fracture of the clavicle in a child. In adults, fracture of the clavicle is four times as frequent in men as in women. In children incomplete fractures are quite common from falls upon the shoulder and hand. (See Fig. 48.)

For purposes of description it is customary to divide fractures of the clavicle into fractures of the middle, outer, and inner thirds of the bone. Fractures of the middle third are much the most frequent.

Causation.—Fractures of the clavicle may be produced by indirect or direct external violence, or by muscular action. The most common type is fracture of the outer portion of the middle third of the bone by indirect violence. The fracture is produced by falls upon the outstretched hand, the elbow being held

FIG. 48.—X-RAY PICTURE OF A GREEN-STICK FRACTURE OF THE CLAVICLE IN A CHILD. (Author's collection.)

rigid, sometimes by falls upon the elbow, or the point of the shoulder. In some cases it is believed that the fracture may occur by falls upon the shoulder, such that the outer end of the clavicle is depressed and that its shaft comes into contact with the first rib, which serves in this case as the fulcrum of a lever against which the bone is broken. Intra-uterine fractures of the clavicle have been observed as the result of external violence and the bone is occasionally broken during parturition by the obstetrician. I saw a case of this kind some two years ago. The fracture was incomplete and healed with but little deformity. Fractures of the outer third are next in order of frequency and fractures of

the inner third are rare. There is usually only a single line of fracture, but more than two fragments are occasionally observed. In this group, if the middle third of the bone constitutes one of the fragments, its displacement may be very marked. Compound fractures, except as the result of gunshot wounds, are extremely rare. Stimson [1] states that he has seen but one case. Simultaneous fracture of both clavicles is also rather a rare injury. I treated one such case. The patient was a man who, finding himself about to be run over by a pair of horses in the street, put out both his hands in front of him and received the impact of the pole of the wagon upon his palms. He sustained fractures of the middle thirds of both clavicles. He was under my care in the New York Hospital, and made a good recovery with but little deformity. The diminution of function is trifling and he is able to follow his occupation, that of chauffeur and mechanic, without difficulty.

Fracture by direct violence may occur in any portion of the bone, but is most frequent in the middle and next in the outer third. It is produced most often by blows and falls upon the clavicle, the force being directed downward and backward. I have seen, and in fact produced, one rather unusual fracture of the clavicle, mentioned under the Diagnosis of Fractures in General. While driving an automobile at night, I ran into an elderly man. The lamp in front of the center of the machine struck him on the right thigh and tossed him up in the air. He came down head first and struck with his left shoulder upon the edge of the metal hood of the engine. A small fragment about an inch in length was chipped off the posterior surface of the outer third of the left clavicle. Strangely enough, although both wheels of the machine subsequently passed over him, he sustained no other serious injury. The diagnosis at the time of the accident was not made, but on the following day it could be made out, though obscured by a large hematoma, which formed upon his shoulder.

The mechanism of the most frequent type of fracture—namely, that of the middle third of the bone—is that the violence is exerted in the direction of the long axis of the bone in such a manner as to increase its normal S-shaped curves; and such violence being continued, the clavicle breaks regularly in its middle third. The line of fracture is usually oblique, and from the anterior border of the bone frequently runs inward and backward, although it may take any direction. It is sometimes transverse, and cases are recorded where it was so oblique as to be almost in the direction of the long axis of the bone.[2] The line of fracture running from the middle of the outer end of the bone toward its sternal end in such a manner that the clavicle has been split into two almost parallel fragments.

The displacement following fractures of the middle third of the clavicle of the oblique variety depends upon gravity and upon muscular action. The outer fragment is firmly attached to the scapula by ligaments and muscles, and the stretcher action of the collar bone being destroyed, the entire shoulder tends

[1] *Loc. cit.*, p. 190.

[2] *Ibid.*, 1900.

to fall forward, downward, and inward. This tendency is increased by the action of the large muscles passing from the thorax to the humerus. The inner fragment, on the other hand, is acted upon by the sterno-mastoid muscle and is drawn upward. Commonly the inner end of the outer fragment slips beneath the outer end of the inner fragment. Angular displacement and the overriding may be very marked and frequently results in considerable shortening of the bone. If the fracture is transverse, overriding rarely takes place. The deformity then present is commonly an angular one, with the apex of the angle directed backward and upward. In oblique fractures the angular displacement and overriding may be extreme. I had one case in a boy of fifteen with a fracture of the right clavicle. The angular deformity and overriding was so great that, union not having occurred after several weeks, I cut down upon the broken bone and so fashioned its fractured ends that they interlocked slightly. A single chromic catgut suture was introduced to hold them during the application of a plaster-of-paris dressing. The patient was kept on his back with a cushion between his shoulders for two weeks. Bony union occurred with very slight deformity.

Diagnosis of Fractures of the Middle Third of the Bone.—In children the diagnosis of incomplete fracture of the middle third can usually be made from the history of the injury, from the localized pain and tenderness, and from comparison with the sound side by appreciating by sight and touch a change in the outline of the bone. In some cases slight mobility may be detected and the bone can usually be bent into nearly its normal contour, sometimes with the appreciation on the part of the surgeon of a slight crepitation. The diagnosis is very readily made by means of an X-ray picture. (See Fig. 48.) The diagnosis of complete oblique fractures of the middle third with displacement is absolutely simple. All the signs of fracture are usually present—deformity, localized tenderness, mobility, sometimes crepitation. This last sign may, however, be absent when the overriding is considerable, until the patient is placed upon his back with a pillow between the shoulders, when the fragments tend to resume their normal relations. Crepitation can then be, as a rule, elicited. Frequently the diagnosis can be made by inspection. The attitude of the patient is quite characteristic. He leans his head and body toward the injured side and supports the forearm and elbow with his other hand. The shoulder droops notably, and if there be much overriding the shortening of the shoulder may be apparent upon inspection.

Fracture of the Outer Third of the Clavicle.—Fracture of the outer third of the clavicle occurs as the result of indirect or direct violence. The line of fracture is commonly transverse, rarely oblique, and the displacement may be slight, considerable, or absent. The commonest form of displacement is angular, with the apex of the angle pointing backward. When the fracture takes place within an inch of the outer end of the bone—namely, outside the attachment of the trapezoid ligament—there is usually marked angular displacement, "the outer fragment turning forward and inward until its axis is at right angles with

that of the inner fragment."[1] The outer end of the inner fragment may slightly override and lie on top of the outer fragment. The displacement is much less marked than in fracture of the middle third, still, all the signs of fracture are usually present. In the absence of displacement, the probable presence and seat of fracture can be determined by finger pressure along the shaft of the bone. When the point of fracture is reached the patient will always complain of pain. Movements of the upper arm will also cause pain at the seat of fracture. The correctness of the diagnosis can often be demonstrated by the formation of a mass of callus producing an enlargement of the bone in the course of a fortnight or so. In some fractures of the outer third where there is no displacement, but where a point of extreme tenderness exists, if the surgeon places his right forearm beneath the axilla of the injured side, while the left second and third fingers are placed over the supposed point of fracture, and then with his right arm raises the shoulder and makes rocking motions up and down, mobility will frequently be detected by the fingers resting upon the clavicle. The fractures just described, in which little or no displacement occurs, are those which take place usually between the conoid and trapezoid ligaments. In some of them, as already noted, there will be an angular displacement. In others the displacement, if the fracture be very close to the outer end of the bone, may nearly resemble a dislocation of the outer end of the clavicle. In any case of doubt as to the existence of fracture, its presence or absence may be demonstrated with certainty by means of one or more good X-ray pictures. In order to show a fracture of the clavicle in this way most clearly the patient should lie prone upon the table. The arm of the injured side may be permitted to hang over the edge of the table, or in some cases the hand of the injured side may be placed behind the patient's back. In some cases the sound shoulder may be supported by a low cushion. The object of the posturing is to bring the entire length of the bone as nearly as possible in contact with the photographic plate, and the position may, of course, be varied slightly to suit the individual case. If stereoscopic pictures be taken in this position a fracture, if present, can always be detected.

Fractures of the Inner Third of the Clavicle.—Fractures of the inner third of the clavicle are extremely rare. They may be produced by direct or indirect violence. The line of fracture is usually oblique. The usual displacement is of the inner end of the outer fragment downward and forward. If the inner fragment is displaced at all, it is apt to be rotated slightly upward.

Prognosis.—The prognosis in fracture of the clavicle as to union and functional result is in most instances excellent. In Germany, where the disabilities following accidents among working people are carefully estimated and paid for by insurance societies under governmental control, it is, however, considered that from ten to fifty per cent of the earning capacity of an individual may be

[1] L. A. Stimson, *loc. cit.*, p. 195, 1907.

lost from a fracture of the clavicle, and in case both clavicles are fractured the disability may amount to fifty per cent.

Complications.—Serious complications are rare in fractures of the clavicle. In a few cases, injuries of the brachial plexus have been recorded, but it seems probable that they were produced, not by the direct action of the broken ends of the bone, but by the same violence which caused the fracture. In a moderate number of instances, as the result of the formation of exuberant callus, pressure symptoms have developed referable to the brachial plexus. In bad cases such symptoms are readily removable by cutting away the excessive callus. A very few instances have been recorded of injuries to the lung and a few of injuries to the subclavian and internal jugular veins. Failure of union is very rare, even in those cases where much overriding takes place, but even in the rare instances where union has not occurred, the functional result has been for the most part satisfactory.

DISLOCATIONS OF THE CLAVICLE

Dislocations of the clavicle constitute in the statistics of most observers about five per cent of all dislocations. The bone is quite firmly held in position by ligaments which attach it to the scapula at its outer end. At its inner end it is attached to the sternum and to the first rib. Dislocations may occur at the outer or inner end of the bone. The former are much the more frequent. A very few cases only of simultaneous dislocation of both ends of the bone—namely, eleven only are recorded.[1]

Dislocations of the Outer End of the Clavicle.—Complete dislocation of the outer end of the clavicle only occurs after rupture of the ligaments of the acromio-clavicular joint and of the conoid and trapezoid ligaments which attach the under surface of the bone to the coracoid process. The incomplete dislocations are not infrequent. The bone may be displaced upward on top of the acromion, or downward and backward, or, very rarely, downward and forward beneath the coracoid process. Dislocation upward is much the most common form. The commonest cause is a blow or fall upon the acromion, such that the scapula is forced downward and at the same time forward or backward and inward. The signs and symptoms of complete dislocations upward are so marked that usually no confusion can arise. When the dislocation is complete the upper end of the clavicle rides upward above the acromion and forms a visible and palpable prominence of the outer part of the shoulder. On account of pain there is marked diminution of function in the shoulder-joint, as a rule. In other cases the patients are able to use the limb quite well, even immediately after the accident. There will also be localized pain and tenderness. The acromion lies beneath the outer end of the clavicle and is displaced downward and inward. Usually a comparison by inspection and palpation of the two shoulders

[1] L. A. Stimson, *loc. cit.*, p. 545, 1907.

is entirely sufficient for the diagnosis. In the incomplete form the clavicle rides up higher than normal above the acromion, but the joint surfaces are not entirely separated. The displacement is readily reduced, but tends to recur. The only error likely to be made is to suppose that the injury is a fracture of the outer end of the clavicle. This can be excluded by following the outline of the outer end of the bone with the fingers and appreciating that its contour is normal, and, further, by comparative measurements of the clavicles of the two sides; further, by the fact that crepitation is absent and that by elevation of the shoulder the deformity is diminished or disappears, but recurs at once. It occasionally happens that in dislocations of the outer end of the clavicle a small fragment of bone is torn away, either from the acromion or from the clavicle, but even in these cases the true condition of affairs is easy to appreciate.

Dislocation Downward of the Outer End of the Clavicle.—This is a very rare form, only twelve cases having been recorded.[1] It has been produced by direct violence, as from a blow or fall which presses the outer end of the clavicle downward. It has also occurred from muscular violence. The symptoms have been marked and the diagnosis in the recorded cases has not been difficult. The pain at the time of the injury has usually been quite severe, and there has been marked functional disability of the upper extremity. In some of the cases pressure symptoms upon the brachial plexus were noted. The inner end of the clavicle appears rather prominent and the bone can be traced outward and will seem to occupy a deeper position than normal until its outer end is lost beneath the prominent acromion. The entire shoulder appears to be somewhat depressed. It is not difficult to identify the articular surface of the acromion and to discover that it is empty and no longer occupied by the clavicle.

Subcoracoid Dislocation of the Clavicle.—A third and exceedingly rare form of dislocation of the outer end of the clavicle has been observed and reported by two surgeons, Godemer and Pinjon. The cases number six, although a few others have been reported in combination with dislocation of the shoulder. In the reported cases the injury has been produced by a fall upon the shoulder. The symptoms were pain and loss of function, marked prominence of the acromion and of the coracoid process, which could be felt beneath the skin, and a deep depression corresponding to the position of the outer end of the clavicle. The end of the clavicle could be felt in the axilla. There was limitation of motion in the arm upward and inward. The shoulder was displaced downward and forward. Reduction does not appear to have been difficult in any of the cases. The correctness of the observations is questioned.[2]

Dislocation of the Sternal End of the Clavicle.—Dislocation of the sternal end of the clavicle is less frequent than that of its outer extremity. The dislocation may take place in three directions. Their frequency is in the order given: (*a*) forward dislocation, (*b*) upward dislocation, (*c*) posterior dislocation.

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[1] L. A. Stimson, *loc. cit.*, p. 542, 1907.

[2] *Ibid.*, p. 545.

Forward Dislocation.—The forward dislocation may be complete or incomplete. In the reported cases the mechanism appears to have been that the shoulder and the outer end of the clavicle were displaced downward and backward until the normal limit of mobility was reached, after which the clavicle came in contact with the first rib, and, this acting as a fulcrum, the anterior and internal end of the bone was pried out of place. The anterior sterno-clavicular ligament is ruptured. The dislocation has been produced by falls upon the shoulder, by severe pressure over the outer end of the clavicle, as in run-over accidents, when the individual was on his back, and occasionally by forcibly bringing together the elbows behind the back. (Richerand.) It has also been produced by muscular violence, as in the act of squaring the shoulders during military drill. (See also Axillary Aneurism.) The dislocation has also been slowly produced in a few cases by gradual relaxation of the ligaments.[1]

The most marked sign of the injury, in addition to local pain and swelling, with loss of function in the arm, is the presence of the dislocated end of the clavicle in front of the sternum. Usually these patients are unable to raise the arm, the shoulder is depressed and the head is bent toward the injured side. If the dislocation is incomplete, the head of the bone is less prominent and the displacement can usually be readily reduced by direct pressure, but tends to reappear at once.[2] In the complete cases reduction is, as a rule, easily made, but hard to maintain.

Upward Dislocations.—The upward dislocations are much more rare than the preceding. When produced by external violence, the force is exerted upon the acromion and outer end of the clavicle to depress the shoulder and thus tearing the upper portion of the capsular ligament of the sterno-clavicular joint, lifting or prying the bone out of its position. If the force continues to press the shoulder toward the median line of the body, the inner end of the clavicle is pushed upward and inward a variable distance. The signs and symptoms produced are the presence of the head of the bone above its normal position and behind the sternal portion of the sterno-cleido-mastoid muscle.[3] This displacement varies greatly in degree. It may be slight or so marked that the inner end of the clavicle is pressed far upward in the neck and across the median line. The symptoms of dyspnea from pressure upon the trachea have been observed in a certain number of cases; more rarely difficulty in swallowing. In addition, the shoulder is depressed and approaches the median line. It is usually possible to feel the notch in the sternum for articulation with the clavicle, empty. In some of the cases, however, the swelling might be so great that this sign could not be detected. In a few cases symptoms referable to pressure upon the phrenic and pneumogastric nerves have been observed. An X-ray picture would show the position of the bone.

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[1] L. A. Stimson, *loc. cit.*, p. 529, 1907. [2] *Ibid.*, p. 531, 1907.
[3] *Ibid.*, p. 534, 1907.

Posterior Dislocation of the Inner End of the Clavicle.—This form may be produced by direct violence, which presses the inner end of the clavicle backward, or by indirect violence, which presses the point of the shoulder forward and inward. In the latter group of cases the injury has been caused usually by lateral compression of the shoulders, as between a railway car and a wall, or some similar accident. In the cases produced by direct violence the causes have been a fall upon the front of the chest, or a blow, or direct pressure as from a heavy body passing across the chest.[1]

The dislocation may be complete or incomplete, and in the complete cases the amount of displacement has varied a good deal in different cases. The principal signs and symptoms are absence of the head of the bone from its proper position, and the presence behind the sternum of a bony mass which moves with motions of the shoulder. Frequently the head of the bone presses upon the trachea, causing dyspnea, less often upon the gullet, causing difficulty in swallowing. In some of the cases venous congestion of the face and neck has occurred, which disappeared after reduction of the dislocation. The shoulder appears depressed and shortened. In addition, there is greater or less loss of function in the upper extremity, caused by pain, and rigidity of the head and neck, for the same reason.

Double Dislocation of the Clavicle.—Double dislocation—i. e., dislocation of both ends of the clavicle—has been recorded in eleven cases. (Stimson.) In all but one the injury was produced by external violence of a severe grade, and the force seems to have been directed from without and behind, forward and inward upon the affected shoulder. In all the cases the inner end of the clavicle has been displaced forward.[2] The displacement of the outer end has been in various directions. The recognition of the condition should be quite simple on inspection and palpation.

The exact diagnosis of any case in which the existence or character of the displacement is doubtful can best be made by a pair of stereoscopic radiographs viewed in the Wheatstone stereoscope.

FRACTURES OF THE SCAPULA

If we except gunshot fractures in time of war and fractures of the acromion process, fractures of the scapula are rare and constitute in the statistics of most observers about 1 per cent of all fractures. It is customary to divide fractures of the scapula, for purposes of description, into several groups, namely: (1) Fractures of the body of the bone, (2) Fractures of the upper angle, (3) Fractures of the lower angle, (4) Fractures of the spine, (5) Fractures of the acromion process, (6) Fractures of the coracoid process, (7) Fractures of the neck of the bone, and (8) Fractures of the glenoid cavity.

[1] L. A. Stimson, *loc. cit.*, p. 532, 1907.

[2] *Ibid.*, p. 545, 1907.

Fractures of the Body of the Bone.—There may be one or several lines of fracture. In the former group the line of fracture may be transverse or oblique, and occurs through the subspinous fossa. Displacement may be absent or very slight; in some cases there is overriding. The lower fragment may be displaced toward the axilla, or in the opposite direction. In multiple fractures the lines of fracture may run in any direction. They are frequently stellate, sometimes with comminution. Gunshot fractures made by modern military bullets of the body of the bone may be clean perforations or be accompanied by fissures, as evidenced by widespread tenderness on palpation. The causes of fracture of the body other than gunshot wounds are usually direct violence, as from blows over the shoulder-blade, or falls upon the back, as in slipping while going downstairs and falling against the angle of a step. All the signs of fracture may be present, or some may be wanting. There is always localized pain on pressure, and such motions of the arm as involve also movement of the scapula will cause marked pain at the seat of fracture. In some cases mobility may be detected by placing the arm in such a position that the scapula flares away from the ribs, as by putting the hand behind the back. If then a finger or two can be inserted below the lower angle of the bone, between it and the ribs, while the other hand grasps the spine and acromion, lifting and rocking motions made by the fingers beneath the lower angle will often permit the surgeon to recognize abnormal mobility and sometimes crepitation. If the patient is not too fat, or very muscular, a departure from the normal in the outline of the bone can usually be detected by palpation, when overriding or lateral displacement exists.

Fractures of the Upper Angle.—Fractures of the upper angle of the bone are exceedingly rare. The line of fracture runs obliquely somewhere above the bottom of the supraspinous fossa, or may extend through the spine into the subspinous fossa. In the few reported cases the fracture has been caused by direct violence. In one case recorded by Gurlt, and quoted by Stimson,[1] the fragment, including the angle of the bone, was drawn upward and inward by the levator anguli scapulæ muscle. The fracture, if present, could be inferred with probability from localized pain and tenderness, increased by elevation of the arm, possibly by grasping the fragment between the fingers and noting its abnormal mobility. The detection of fractures of the body of the scapula by means of the X-rays, the shoulder-blade being placed over the plate, would probably require the use of a tube of low resistance, unless there were fairly marked displacement, since the top of the bone, as well as the portion projecting above the spine, is so thin that it casts a very faint shadow.

Fractures of the Spine of the Scapula.—Fractures of the spine of the scapula are rare. They have been produced by direct violence, as from a blow from behind, downward and forward against the prominent edge of the bone near the acromion. Personally I have seen but one case, produced by a fall upon

[1] L. A. Stimson, *loc. cit.*, p. 209, 1900.

the back. There was a marked contusion over the scapula and a considerable hematoma. The signs of fracture, localized tenderness, mobility and crepitation, were present. Stimson states that no preparation of an isolated fracture of the spine of the scapula is known, the knowledge of the fracture being, therefore, purely clinical.

Fractures of the Acromion Process.—Fractures of the acromion process of the scapula may be produced by direct violence, as from a blow upon the shoulder, or indirectly by falls upon the hand or elbow. Up to the twentieth year separation of the epiphysis may occur. The diagnosis is, as a rule, entirely simple. All the signs of fracture are present. The deformity may be slight if the fracture is near the tip of the process; or, on the other hand, if the greater portion of the acromion is broken off, there will be some falling of the shoulder, and palpation will usually permit the surgeon to feel a gap in the bone, sometimes the prominent ridge of the inner edge of the smaller fragment. The motions of the arm are greatly restricted on account of pain. Abduction is usually impossible. If only a small portion of the bone is broken off, the fragment may be drawn downward by the fibers of the deltoid, so that considerable separation is observed. All the other positive signs of fracture may be elicited by movements of the arm, or by passive movements of the smaller fragment.

Fracture of the Coracoid Process.—Fracture of the coracoid process may occur as the result of direct or indirect external violence, occasionally from muscular action. The fractures by direct violence are frequently complicated by associated injuries, such as fractures of other portions of the scapula, the humerus, and fracture of the clavicle or ribs. Fractures by indirect violence have been caused by severe blows and falls upon the shoulder. The fractures produced by muscular action have usually resulted from violent muscular efforts. Fractures by indirect violence have sometimes been caused by force transmitted through the dislocated head of the humerus, in other cases by pressure of the tip of the process against the clavicle in forced flexion of the shoulder. (Lane, quoted by Stimson.) The line of fracture usually runs about an inch from the tip of the process, but may be close to its base. The signs and symptoms are localized pain and tenderness; pain on motion of the arm, notably by voluntary flexion and adduction;[1] pain on deep inspiration, owing to the contraction of the pectoralis minor. The signs of mobility and crepitation are not always easily made out on account of the extravasation of blood and swelling. In some cases, where the violence has been extreme, the ligamentous attachments to the process being torn, the fragment is dragged downward and inward by the attached muscles, and in some cases such displacement has been appreciable.

Fractures of the Neck of the Scapula.—A very small number only of these fractures have been subjected to anatomical dissection. Stimson[2] was able to collect only six cases from the literature. The line of fracture may run from

[1] L. A. Stimson, *loc. cit.*, p. 211, 1900.

[2] *Ibid.*, p. 214, 1907.

the suprascapular notch downward to the axillary border of the bone, in a direction nearly parallel with the articular surface of the glenoid cavity, or it may begin at or near the upper border of the articular surface and run downward to the axillary border. The fracture occurs when the arm, being rotated outward, direct violence is applied from behind against the head of the humerus, or by a blow upon the elbow when the arm is directed backward.[1] The signs and symptoms of this fracture closely resemble in many respects dislocations of the humerus. The shoulder is flattened, the acromion is prominent, there is, as a rule, entire inability to move the arm. Passive motion, however, is possible and is not necessarily painful. The most characteristic sign is that the displacement is readily reduced by lifting the arm directly upward, but recurs at once. The reduction of the displacement, as indicated, is sometimes accompanied by crepitus and always by severe pain. In some cases the fragment could be palpated in the axilla. In general the diagnosis is quite simple, as above described, the important difference from a dislocation of the humerus being that the deformity and displacement in the fracture is readily reduced, but at once recurs.

Fractures of the Glenoid Cavity.—As a complication of dislocation of the shoulder-joint, chipping off of a portion of the border of the glenoid cavity is not rare. The fracture commonly involves only a small portion of the articular surface, and in the cases studied anatomically the inner border has been the part most often involved, although cases have been recorded in which the articular surface was split into several fragments. The diagnosis could best be made by means of stereoscopic X-ray pictures.

INJURIES OF THE SHOULDER-JOINT

Contusions and Sprains.—The soft parts surrounding the shoulder-joint are peculiarly liable to injuries from external violence, such as blows and falls upon the shoulder. The diagnosis of these conditions in the absence of the signs of fracture does not, as a rule, offer great difficulties. In a considerable number of cases, however, where the injury has been quite severe, swelling and ecchymosis may render palpation of the upper end of the humerus quite difficult. Pain and the fear of pain, as well as the actual contusion and laceration of the fibers of the deltoid muscle, may produce very marked loss of function, abduction of the arm being frequently extremely painful or impossible. In some of these cases there will be found, upon careful X-ray examination, an injury to the bones. I have repeatedly seen impacted fractures of the surgical neck of the humerus, attended by much swelling around the shoulder-joint, where very competent surgeons were unable, by ordinary means of examination, to recognize the presence of a fracture. In several cases, where the greater tuberosity of the humerus had been torn away by muscular violence or fractured

[1] Farabeuf, quoted by Stimson, *loc. cit.*, p. 212, 1900.

directly by a fall upon the shoulder, the diagnosis has been obscure by ordinary methods of examination.

It is in these cases that the X-rays are particularly valuable diagnostic aids, and where any doubt exists as to the nature of the injury it is the duty of the surgeon, not only on account of the patient but also on his own, to have X-ray pictures taken. In many instances in my experience the presence of injuries of the bone has been demonstrated or eliminated with certainty.

Following even moderately severe sprains and contusions of the shoulder-joint, one practical point should be especially borne in mind—namely, that on account of pain patients avoid abduction of the arm, and if let alone they will keep the arm close to the body, usually in a sling, for several weeks. When the attempt to abduct the arm is renewed, the patient suffers pain and is tempted to avoid such movements. The more severe the injury, the sooner will adhesions take place within the joint and in the surrounding soft parts; and in a comparatively short time so great a degree of stiffness will result that, unless passive movements are made and the patient instructed to make active movements of abduction and elevation of the arm himself, a permanent limitation of motion may result.

Open Wounds of the Shoulder-joint.—Stab and punctured wounds of the shoulder-joint may be followed by infection. It will rarely be possible, when the shoulder-joint is thus wounded, to verify the condition by recognizing the escape of synovial fluid. In most instances the development of infection of the joint will be the earliest evidence that it has been opened. There will then be developed the general symptoms of sepsis, as well as pain with swelling and infiltration of the surrounding soft parts and absolute loss of function in the joint.

Gunshot Wounds of the Shoulder-joint.—Gunshot wounds of the upper end of the humerus are fairly common in time of war. The character of the fractures produced will vary according to the character of the weapon, the range, etc., as already described under Gunshot Wounds. A clean perforation of the spongy head of the bone is quite possible with the modern small-calibered bullet. If the surgical neck is the part struck, splintering and comminution, with fissures running in various directions, are common. The diagnosis of the character of the injury is to be made partly by the signs of fracture, if such exist. The actual nature and extent of the injury to the bone can best be recognized by means of the X-rays.

In the shoulder, as elsewhere, primary union without marked disability resulting is to be expected in a large proportion of cases, if an occlusive dressing is at once applied and the wound is not interfered with. Immobilization of the arm is an important part of the treatment. The special signs and symptoms of purulent inflammation of the should-joint will be spoken of under Diseases of the Shoulder-joint.

FRACTURES OF THE HUMERUS

The very large series of photographs of fracture of the humerus contained in this and the following sections were made in the Anatomical Department of the College of Physicians and Surgeons, Columbia University, by Dr. Adrian V. S. Lambert. They form a very beautiful and complete series, showing a great variety of types of fracture and of displacements. The total number of these pictures was so large that I have been able to utilize only a fraction of them. I wish here to express my gratitude to Dr. Lambert and to Dr. Joseph A. Blake, for whom the pictures were originally taken, for permitting me to use them. They were taken, I believe, with the idea of showing that, though there may be typical displacements in fractures of certain parts of special bones yet that in fractures the displacements are of a very varied character and depend largely upon the direction of the line of fracture with reference to the long diameter of the bone, upon the character and extent of comminution and of crushing, rather than upon the influence of muscular contraction in particular directions. Thus, in the series of fractures of the surgical neck of the humerus, it will be observed that rotary, angular, and longitudinal displacements may occur in almost any possible direction. Thus, in studying the preparations of fractures of the surgical neck, Dr. Lambert observed the following conditions: The upper fragment may be abducted, flexed and rotated outward. The position of the lower fragment may be upon the inner side, upon the outer side, or posterior.

In some cases, impaction may occur over the entire surface of the fracture. The inner surface of the lower fragment may be impacted into the upper fragment. The impaction may be irregular and thus in any possible direction. In fractures which involve wholly or partly the line of the anatomical neck the head may be driven into the tuberosities. The head may be displaced downward on the inner surface of the shaft. The head may be rotated. There may be nonunion. The head may be displaced into the axilla. For further details the reader will consult the following sections.

Fracture of the humerus, although a very common injury, constituting from 4 to 7 per cent of all fractures in the statistics of different observers, is less frequent than fracture of the clavicle or forearm. The injury is nearly twenty times as frequent in men as in women, and the majority of the fractures occur during the first two decades of life. Fractures of the upper end of the bone are commonly grouped under (1) Fractures of the head, (2) Fractures of the anatomical neck, (3) Fractures through the tuberosities, (4) Fractures of the tuberosities, (5) Separation of the epiphysis, (6) Fractures of the surgical neck.

Fractures of the Head of the Bone.—Fractures of the head of the bone, in which merely a small fragment of the articular surface is separated without involvement of other parts, are believed to be extremely rare. I have seen one case in which, after a fall upon the shoulder, the patient suffered great pain

and marked disability. The X-ray picture seemed to show that a small fragment of bone had been broken from the upper part of the articular surface of the humerus. The question of the operative removal of the fragment was considered, but was refused by the patient. At the end of six weeks the motion

FIG. 49.—FRACTURE OF THE ANATOMICAL NECK OF THE HUMERUS, SPLINTERING OF THE GREATER TUBEROSITY. Impaction, with outward displacement. Obliteration of the bicipital groove.

FIG. 50.—POSTERIOR VIEW OF FIG. 49.

in the shoulder-joint was so far restored that the patient withdrew himself from observation. In dislocations of the shoulder it not infrequently happens that the head of the bone is more or less deeply grooved by the edge of the articular surface of the scapula.

Fracture of the Anatomical Neck.—Fracture of the anatomical neck of the humerus is regarded as a very rare injury; that is to say, cases in which the line of fracture does not pass through the tuberosities. The line of fracture

runs entirely within the capsule of the joint. Since the X-rays have come to be generally used in the diagnosis of injuries of the shoulder-joint, many instances of fractures of the anatomical neck have been recorded. In the opinion of Scudder [1] this fracture is more common than is generally supposed. He believes that it is frequently impacted and passes unrecognized. By ordinary methods of examination the fracture is hard to make out. There is swelling and pain in the region of the shoulder-joint, together with loss of function. Crowding the arm upward toward the glenoid cavity causes pain. Crepitus may be absent, since the separated head of the bone may readily move in company with the shaft within the joint capsule when rotary motions are made of the latter. The most certain means of diagnosis is by taking stereoscopic X-ray pictures.

Fig. 51.—External View of Fig. 49.

Fig. 52.—Section of the Head of the Bone in Fig. 49.

[1] "The Treatment of Fractures," Chas. L. Scudder. Saunders, 1907.

I had one undoubted case of fracture of the anatomical neck of the humer in the Roosevelt Hospital. The patient was an elderly woman in whom I ma the probable diagnosis of fracture of the anatomical neck of the humerus. Aft

FIG. 53.—RIGHT HUMERUS. Fracture of the upper end of the bone with splintering of the great tuberosity; exostosis of the articular head. "The fracture line runs from the lower border of the articular surface of the humerus internally, passing anteriorly along the anatomical neck to the center of the bone. It then passes outward below the lesser tuberosity and obliquely downward interrupting the bicipital groove in front. Posteriorly, the line of fracture passes transversely below the base of the greater tuberosity."

FIG. 54.—POSTERIOR VIEW OF FIG. 53.

the patient had been in the hospital f several weeks suppuration occurred i the joint. I cut down upon the shou der-joint and removed the separate articular portion of the head. The was no evidence of an effort towa union. The head of the bone was e tirely loose within the joint capsule. The functional result was quite goo although before the patient was entirely well she passed out of observation.

Fractures of the Anatomical Neck of the Humerus with Dislocation of the Head.—J. J. Buchanan published a report of the recorded cases of this injury in the *Annals of Surgery* for May, 1908. He was able to collect thirty-four undoubted cases and nine unverified. The report includes one of his own, in which he removed the head of the bone with good result. In his case the ordinary signs of dislocation were not present. The shoulder was not notably flattened. The elbow could be applied to the chest wall and the hand placed upon the opposite shoulder. The tuberosities could be felt to rotate with the shaft. Crepitation was absent. The X-ray examination demonstrated the existence of a fracture of the anatomical neck with subglenoid or axillary dislocation of the head.

Fractures Through the Tuberosities.—Fracture of the anatomical neck through the tuberosities is more frequent than the preceding form, and has been observed a number of times in conjunction with dislocation of the head of the bone. It would scarcely be possible to differentiate between this form of fracture and fracture of the surgical neck proper, except by an X-ray picture, and only then if pictures of good quality were obtained.

Fractures of the Tuberosities.—Tearing off of one or more fragments of bone to which the spinati and teres minor muscles are attached is not very rare as a complication of anterior dislocations of the shoulder. Stimson considers it very rare, as an isolated injury. In the few recorded cases in which it is certain that no dislocation existed the mechanism of the fracture appears to have been due, in most instances at least, to muscular action. Stimson describes a case which he saw, produced by violent outward rotation of the arm made by a young man in striving to ward off a blow from a horse which had reared and was about to fall on top of him. The signs and symptoms observed were as follows:

> The left shoulder was somewhat swollen, there was an ecchymosis at the lower border of the tendon of the pectoralis major muscle; voluntary abduction possible; voluntary rotation impossible; firm pressure upward at the elbow painless. The lesser tuberosity moved with the shaft on rotation. Pain on pressure upon the greater tuberosity. I inserted an insect-pin in front at the bicipital groove and passed it backward its full length evidently between two bony surfaces; and by pressing its point against the inner one and rotating the arm the continuity of this surface with the shaft was shown. My diagnosis was fracture of the greater tuberosity by muscular action, by outward rotation of the arm in the effort to ward off the descending body of the horse.[1]

In one case I made at least a probable diagnosis of fracture of the greater tuberosity by muscular violence. The patient had thrown out his arm violently while trying to save himself from a fall and felt a sharp pain in his shoulder, greatly increased by attempts to rotate the arm outwardly. There was marked

[1] L. A. Stimson, *loc. cit.*, p. 223, 1907.

tenderness over the site of the greater tuberosity, and an X-ray picture showed a small shadow which seemed to represent a fragment of bone torn off from this part of the humerus. The patient made a satisfactory recovery, without any treatment further than immobilization of the arm in a sling.

Fracture of the greater tuberosity of the humerus may also occur as the result of direct or indirect violence applied to the shoulder or upon the outstretched hand, respectively. H. L. Taylor, *Annals of Surgery*, January, 1908, p. 10, reports two cases of this description verified by X-ray pictures. In both cases all motions of the shoulder were painful. External rotation and abduction were abolished and passive motions of these characters gave great pain. In each case there was much swelling and ecchymosis of the shoulder and arm. Crepitation was not recognized in either case. There was marked

FIG. 55.—EXTERNAL VIEW OF FIG. 53.

FIG. 56.—VIEW FROM ABOVE OF HUMERUS, SHOWN IN FIG. 53.

tenderness over the head of the humerus, the displacement as shown by the X-ray was slight. Both patients made good functional recovery without other treatment than support of the arm.

Fracture of the Lesser Tuberosity.—Even as a complication of dislocations of the shoulder, tearing off of the lesser tuberosity is generally regarded as a rare injury. In the few recorded cases, which have been carefully studied, the

injury has been produced by forcible external rotation of the arm. The symptoms have been pain and disability referred to the shoulder, with diminution of voluntary internal rotation and an increase in outward rotation. There has been no external deformity, and in one case, that of Lorenz, quoted by Stimson,

Fig. 57.—Separation of the Upper Epiphysis of the Humerus; Union with Some Displacement. Showing ossification in the periosteal sleeve which has been stripped away from the inner and posterior aspect of the bone. (Author's collection.)

a small movable piece of bone was felt beneath the coracoid process and a sharp edge could be felt upon the head, which seemed to indicate a loss of substance. The diagnosis could probably be made by taking stereoscopic pictures, with the plate against the front of the shoulder.

Separation of the Upper Epiphysis of the Humerus.—The upper epiphysis consists of the head and the tuberosities of the bone. Beginning upon the inner side, the line of the epiphyseal cartilage corresponds throughout its inner third with the groove of the anatomical neck. Thence it runs horizontally outward, passing just beneath the tuberosities. The lower surface of the epiphysis is somewhat cup-shaped, so that the upper end of the shaft is higher in the middle than at the periphery, and fits into the cup-shaped depression in the head. The projection of the upper end of the shaft becomes more marked with advancing

years, until it unites, usually at about the twentieth year of life, with the head. The separation occurs seldom before the sixth year of life, and probably not after the age of twenty. It has, however, been observed in infants as the result

FIG. 58.—FRACTURE OF THE ANATOMICAL NECK OF THE HUMERUS WITH SPLINTERING OF THE GREATER TUBEROSITY. The head is displaced downward and backward upon the shaft. There is evidence of partial impaction. Anterior view.

FIG. 59.—POSTERIOR VIEW OF FIG. 58.

FIG. 60.—EXTERNAL VIEW OF FIG. 58, SHOWING THAT THE UPPER END OF THE SHAFT IS FREE UPON ITS OUTER ASPECT. There is a marked production of osteophytes.

of traction upon the arm, with the finger hooked in the axilla, while some pressure inward was exerted upon the outer surface of the shaft of the humerus. The line of fracture usually corresponds closely with the epiphyseal cartilage. The fracture has been produced by falls upon the shoulder and by forcible elevation of the arm, less commonly by violence transmitted through the shaft

of the bone by falls upon the elbow. The symptoms and signs are usually characteristic. The normal rotundity of the shoulder is preserved. The most common form of displacement is that the head of the bone is rotated by the muscles attached to the tuberosities in such a manner that the articular surface is directed downward, while the fractured surface looks outward. The upper end of the shaft is usually displaced forward and is often caught by its sharp anterior edge in the subcutaneous tissues. The shaft of the bone is usually directed a little backward. It may be abducted. The projecting end of the lower fragment can often be seen forming a prominence below the shoulder with a corresponding pit above it. The appearance is, in many cases, quite characteristic.

In a smaller number of cases the upper end of the shaft is displaced inward, so that it comes to lie beneath the coracoid process. In some cases it is displaced outward, although this displacement is more common in fractures through the surgical neck. In addition to pain and disability, there may be a soft crepitation upon rotation of the shaft of the bone. If the left hand grasps the shoulder from above in such a manner that the forefinger and the third finger are placed one on either side of the lesser tuberosity, while the right hand grasps the elbow and makes rotary movements of the shaft, it will be found that the head does not rotate with the shaft. In some cases there is no displacement, and in such the diagnosis must be made by the pain and disability. Displacement, however slight, can usually be detected by the X-rays. In many of these cases the periosteum upon the inner and posterior aspects of the bone remains attached to the head and is stripped away from the shaft for a variable distance downward. This condition is well shown in the X-ray picture of a child who came under the author's observation some years ago. As will be noted, in this case the displacement had been incompletely reduced and ossification along the periosteal bridge is clearly shown. When, as in this instance, the displacement is not completely reduced, some limitation of motion may remain after the injury is healed. The child may be unable to abduct the arm fully, and rotation may also be more or less limited. A more serious consequence of some of these injuries is that the growth of the humerus upon the injured side may be interfered with, so that, as the child grows up, the upper arm remains shorter than its fellow.

Fractures of the Surgical Neck of the Humerus.—Fractures of the upper part of the humerus anywhere below the anatomical neck and above the attachment of the pectoralis major muscle are grouped under the head of fractures of the surgical neck of the bone. The grouping is somewhat artificial, since many of the cases, notably if the line of fracture is oblique, involve in part a portion of the bone below the above-mentioned anatomical limit. These fractures are very frequent. They occur usually in adults and in general represent what would be a separation of the epiphysis were the patient a child. The fracture may occur from numerous kinds of external violence, very rarely from muscular action. Thus, falls upon the elbow or hand, blows directly upon the upper

fragment is acted upon by the muscles attached to the tuberosities and is abducted, flexed, and rotated outward. The usual displacement of the lower fragment when the fracture is not impacted is forward and inward, the shaft of the bone being drawn toward the axilla by the powerful muscles passing to it from the chest. In other cases, notably if the line of fracture passes obliquely from without, downward and inward, the lower fragment will be acted upon by the deltoid and may be drawn upward and outward, though this is by no means as common a type of displacement as that to the inner side.

The Symptoms and Diagnosis of Fracture of the Surgical Neck of the Humerus.—There is usually total loss of power in the arm. If, however, the fracture is impacted, some motions may still be made. If the upper end of the lower fragment is displaced to the inner side, there will be slight abduction of the limb, and if this displacement is extreme, the axis of the limb may take the same direction which it does in anterior and internal dislocations of the shoulder-joint. That is to say, the abduction of the elbow will be quite marked. In some cases of impaction, and also of complete separation of the two fragments, there may be slight measured shortening of the humerus, discoverable by comparing the distance upon the two sides of the body from the tip of the acromion process to the external condyle of the humerus. This shortening is, however, often small in amount, and owing to the marked swelling in the vicinity of the shoulder, and often of the entire upper arm, if the patient is not seen for some hours after the accident it will be difficult, or impossible, to take the measurements accurately. The diagnostic signs of the fracture are as follows: Crowding upward of the elbow in the direction of the axilla causes pain and may be attended by crepitation. If the fracture be not impacted the head of the bone will not follow the shaft when the latter is rotated. In making the examination the surgeon tries to get his left forefinger into the bicipital groove between the tuberosities, while with the other hand grasping the elbow he makes slight rotary movements of the shaft. If the head of the bone does not also rotate, a fracture is certainly present. When these fractures are impacted the exact diagnosis of the injury, including the character of the impaction, the associated injuries to the upper fragment and the relative position of the two fragments, can best be discovered by stereoscopic X-ray pictures of the part.

On account of the considerable swelling, and of the marked effusion of blood into the tissues about the shoulder and of the difficulty of getting the injured shoulder close to the photographic plate, it is not always easy to obtain good radiographs of these cases; when obtained, however, such pictures are worth all they cost in time and trouble to produce, since the information thus obtainable is very accurate indeed. In ordinary cases the diagnosis of these fractures is quite simple; all the signs of fracture are present. In the absence of mobility and crepitation between the fragments, the pain, tenderness, and disability, together with the very extensive swelling and ecchymosis of the shoulder and arm, which frequently accompanies these fractures, will make

the diagnosis of a fracture of the upper part of the humerus highly probable. The probability can be made a certainty by the use of the X-rays as described.

Serious complications, as the result of fractures of the surgical neck of the humerus, are rather rare. Injury of the axillary vessels is very rare. In-

FIG. 66.—ANTERIOR VIEW OF FRACTURE OF THE SURGICAL NECK OF THE LEFT HUMERUS. The head is rotated backward, the upper fragment is displaced downward upon the shaft.

FIG. 67.—POSTERIOR VIEW OF THE FRACTURE OF THE SURGICAL NECK OF THE HUMERUS SHOWN IN FIG. 66.

FIG. 68.—INTERNAL ASPECT OF FRACTURE OF THE SURGICAL NECK OF THE HUMERUS SHOWN IN FIG. 66.

juries to the cords of the brachial plexus, and of these most often to the musculo-spiral nerve, are occasionally observed. The symptoms of the latter condition are described under Injuries of Nerves of the Upper Extremity. The fracture is very rarely compounded; occasionally it happens that the sharp end of the lower fragment is caught in, or even penetrates the skin, rendering the fracture compound. The shoulder is not flattened, the head of the bone

remains in the glenoid cavity; thus dislocation of the humerus is readily excluded.

Fractures of the Shaft of the Humerus.—Fractures of the shaft of the humerus are extremely frequent. The fracture may occur anywhere between the insertion of the pectoralis major and the supracondyloid ridges. The commonest site is at the middle, or at the junction of the lower and middle thirds of the bone. The humerus may be broken by direct or indirect violence, and is broken by muscular action more often than any bone in the body. The act most often causing fracture by muscular violence is that of throwing a stone or some similar effort. A *spiral fracture* of the humerus may be produced by the

FIG. 69.—FRACTURE OF THE SURGICAL NECK OF THE HUMERUS. The upper fragment is displaced downward and to the inner side. Evidence of comminution.

FIG. 70.—EXTERNAL VIEW OF FIG. 69.

FIG. 71.—INTERNAL VIEW OF FIG. 69.

the nerves, notably the musculo-spiral. As an end result, failure of union is more common in this bone than in any other. The injuries to the vessels may be produced by the violence which caused the fracture directly, or the brachial artery or its accompanying veins may be torn by the sharp fragments of bone. This is an extremely common accident in compound fractures of the humerus the result of crushing violence. The dangers of injury to the vessels are, as elsewhere pointed out, thrombosis, and sometimes gangrene of the limb, or if acute pyogenic infection occurs, one or other of the severer forms of purulent and necrotic inflammation.

The *musculo-spiral nerve* may be injured at the time of the accident, or may be included in callus formation or new bone. The disturbances of its function may be complete or incomplete, as elsewhere described. (See Injuries of Nerves.)

Failure of Union (*Delayed Union, Fibrous Union, Pseudarthrosis*).—The process of repair and the formation of bony union are delayed in fractures of the shaft of the humerus more often than after fractures of the shafts of other long bones. As stated in Volume I, under Fractures, it is difficult to place a time limit in these cases and to say with positiveness that union by bone will not take place provided the ends of the bone are in apposition, with certain exceptions to be noted.

Causes of Failure of Union.—The causes of delay or of failure of union may be general or local; the latter are more frequent and more important. Among the general causes to which failure of union has been attributed may be mentioned depressed states of vitality from acute or chronic disease, from imperfect nutrition, and from specific poisoning, as from syphilis and other chronic infectious diseases. It is to be borne in mind that failure of union from general causes is exceptional.

The *local causes* are numerous. In certain situations union of fracture by bone except as the result of suture or other operative measure upon the fragments is rare. The patella, the olecranon process of the ulna, and the narrow portion of the neck of the femur unite by fibrous tissue merely, in the majority of instances. In the fractures of the shaft of the long bones the most frequent causes of failure of union are the interposition of muscle between the ends of the fragments, imperfect reduction and *imperfect immobilization of the fragments.* This last cause is no doubt very frequent in fractures of the shaft of the humerus, notably in fractures of the lower third, and may be attributed to the fact that unless the dressing extends from the wrist upward and also immobilizes the shoulder-joint, slight movements of the elbow, as of flexion or extension, will cause some motion between the ends of the bony fragments.

Total rupture of the periosteal bridge passing from one fragment to the other is a condition which strongly favors nonunion. It is sometimes observed in simple fractures, more commonly in compound fractures, notably in those where the bone is comminuted, or where one or more separate fragments lie unattached between the main fragments of the bone. In certain cases the presence of such

a loose fragment will in itself prevent bony union. In compound fractures a loss of substance, considerable in extent, between the main bony fragments may delay or prevent the occurrence of bony union. In certain situations, notably in the leg and in the forearm where two bones exist and where both are fractured, one may unite, whereas a rarefying osteitis may occur in the ends of the

FIG. 75.—LEFT HUMERUS, SHOWING FRACTURE OF THE UPPER THIRD OF THE SHAFT AND FRACTURE OF THE SURGICAL NECK. External aspect of the bone. There is a very oblique line of fracture in the shaft running from within outward and from above downward. The upper fragment is displaced outward and downward, the obliquity of the line of fracture determining the displacement.

FIG. 76.—POSTERIOR ASPECT OF FRACTURE OF UPPER THIRD OF SHAFT AND OF SURGICAL NECK SHOWN IN FIG. 75.

fragments of the other bone, such that a gap exists between them too great to be bridged over by bony tissue. I have noticed this particularly in fractures of the radius and ulna. The progress of the condition can be watched by taking a series of X-ray pictures at intervals of several weeks. The space be-

tween the ends of the bone may be seen to increase, the ends of the fragme diminish in size and become more or less conical.

In compound fractures infection is a frequent cause of delayed u and may result in its total failure. This is not only true of severe grad

FIG. 77.—MULTIPLE FRACTURE OF THE HUMERUS. Fracture of the shaft in its upper portion of its middle third and fracture just below the surgical neck. Marked deformity.

FIG. 78.—INTERNAL ASPECT OF THE HU SHOWN IN FIG. 77.

infection such as end in more or less extensive necrosis with loss of subst but also in slighter forms attended only by moderate suppuration. L Stimson [1] considers that—

The operative treatment of simple fractures is responsible for delayed unio for failure of union in certain cases. 1. It is, I think, certain that repa

[1] *The Journal of the American Medical Association*, March 27, 1909, vol. lii, p. 1006.

slower after an operation in which the fragments have been temporarily still further displaced, as has to be done for the placing of a suture. The reason is, I believe, in the additional laceration of the periosteum, the destruction of the periosteal bridge which plays so prompt and important a part in the repair of a fracture, and the stripping back of the periosteum at the edge of the fracture. A delay of one or even several weeks might be of no great price to pay for a material gain, but

FIG. 79.—POSTERIOR VIEW OF MULTIPLE FRACTURE OF THE SHAFT IN ITS UPWARD THIRD AND AT THE JUNCTION OF THE SHAFT WITH THE SURGICAL NECK SHOWN IN FIG. 77.

FIG. 80.—MULTIPLE FRACTURES OF THE SHAFT OF THE HUMERUS. Anterior view shown in Fig. 77.

a similar and far more important disadvantage is found in the suture or pin used to fasten the bones together. That this is in itself sufficient to cause failure of union I am convinced by many observations. It does so by exaggerating the rarefying osteitis which is a necessary preliminary to reunion, and possibly by inhibiting the productive and condensing osteitis which should follow. Thus is created a gap

between the fragments, which is occupied by fibrous tissue showing no tendency to change into bone, a gap equivalent in its effects to a loss of substance or to a displacement similar to that which it may have been the object of the operation to correct.

This condition is habitually observed whenever a wire suture has been applied. I have frequently had occasion to cut down on and remove such sutures, and

FIG. 81.—FRACTURE OF THE SURGICAL NECK OF THE HUMERUS WITH SPLITTING OF THE HEAD AND IMPACTION. Patient was an old woman. (Author's collection.)

have always found them lying loose, all the bone originally embraced within the loop having disappeared. Many similar observations have been made with the X-rays. This occurrence is constant when metal is used, either as a suture or as a pin, and sometimes the loss is so great as to reduce the ends of the fragments to small, widely separated, conical points. Whether the same result follows the use of silk or silkworm gut for suture I do not know, for I have used these materials only as temporary sutures, when the wound had to remain open, and have removed them after a week or two. In other cases I have always used strong catgut, simple or chromicized, trusting to external support for the later maintenance of apposition.

2. As already mentioned, the manipulations necessary in drilling and suturing the fragments delay reunion, probably by additional injury to the periosteum. But in addition to this the added injury to the soft parts, especially when the bone is

Fig. 82.—Fracture of the Surgical Neck of the Humerus. X-ray photograph taken eight months after the injury. Good functional result. (Author's collection.)

Fig. 83.—Fracture Dislocation of the Surgical Neck of the Humerus. (New York Hospital collection. Service of Dr. F. W. Murray.)

not subcutaneous, has two serious drawbacks. It exposes to suppuration t extent which ample experience has shown to be in excess of that pertaining to clean operations, and it notably increases the chance of limitation of motion i neighboring distal joint by cicatricial change in the wounded muscles or by cicatricial attachment to the callus.

Disease of bone, whether due to pyogenic organisms, tuberculosis, syp or to the formation of a sarcoma or a carcinoma in the bone, may be caus delayed union, or of failure of union.

Diagnosis of Delayed Union or Failure of Union.—The diagnosis o layed union or failure of union in the shaft of the humerus is made by

FIG. 84.—FRACTURE OF THE SHAFT OF THE HUMERUS AT ITS MIDDLE THIRD. Anterior view.

FIG. 85.—POSTERIOR VIEW OF FRACTURE SHAFT OF THE HUMERUS SHOWN IN FIG

detection of mobility between the fragments. If the fracture is near a such mobility may be hard or impossible to detect by palpation. In these

the X-rays are invaluable. Stereoscopic pictures will show the absence of ossification between the fragments, or, on the other hand, new bone, even though small in amount, will cast a definite shadow such that the probability of final union may be predicted.

Pseudarthrosis.—The formation of a false joint at the seat of fracture is more frequent in fractures of the shaft of the humerus than elsewhere. The

FIG. 86.—FRACTURE OF THE SHAFT OF THE HUMERUS WITH OVERRIDING.
The patient was a child. X-ray by the author.

condition is, however, rare in any situation. Its recognition is very simple. A sort of imperfect joint is formed between the bony fragments, the ends of the bones are united by fibrous tissue forming a capsule within which, between the fragments, there is a cavity containing fluid resembling synovia. The ends of the bone may be covered with fibrous tissue, with cartilage, or they may simply be eburnated. While the exact condition can only be appreciated by an open operation, the absence of union is, of course, entirely evident.

DISLOCATIONS OF THE SHOULDER

The shoulder is dislocated more often than any other joint in the body. Dislocations of the shoulder constitute about half of all dislocations. The injury is rare in childhood, common during the middle period of life, and more

frequent in men than in women during this time. In advanced age the injury occurs with about equal frequency in both sexes. The position of abduction and outward rotation of the humerus is the most favorable position of the limb

FIG. 87.—FRACTURE OF THE SURGICAL NECK OF THE HUMERUS WITH IMPACTION. (Author's collection.)

for the production of dislocation upon the application of suitable violence. Among English and American writers the following classification is usually adopted for dislocations of the shoulder. It is that adopted by Stimson:

A. Anterior or forward dislocations.
   1. Subcoracoid.
   2. Subclavicular or Intracoracoid.
B. Downward dislocations.
   Subglenoid, of which the Erect Dislocation is a variety.
C. Posterior, or backward dislocations.
   1. Subacromial.
   2. Subspinous.
D. Upward dislocations.
   Supraglenoid.

Dislocation of the shoulder may be produced by direct violence, or by indirect violence, or by muscular action. The most frequent method of production is by indirect violence, as from a fall upon the hand, or upon the elbow, while the arm is abducted and rotated outward. In this position the head of the bone is pressed against the weakest portion of the capsule—namely, at its lower and inner part. Moreover, the greater tuberosity of the humerus comes into contact with the upper edge of the glenoid cavity, and if the motion of abduction is continued, the tuberosity acts as a center of motion, the edge of the glenoid fossa as a fulcrum, the capsule is put still further upon the stretch, and finally torn so that the bone slips through the rent out of its socket. The anterior and internal displacement is increased by the action of the deltoid, the pectoralis major, the latissimus dorsi muscles. This very briefly outlined mechanism produces the anterior and internal varieties of dislocation, which constitute the vast majority of all dislocations of the shoulder. In some cases the head of the bone may rest against the lower border of the glenoid cavity, constituting a subglenoid or, in rare instances, an erect dislocation. In the far rarer posterior dislocations the head of the bone slips upward and backward and remains beneath the acromion, or the spine of the scapula, constituting the subacromial and subspinous varieties, respectively.

Dislocations by direct violence occur from blows upon the shoulder in a downward and inward direction when the arm is abducted. The displacement is aided by extensive laceration of the capsule and by the contraction of the muscles after the head of the bone has left the glenoid fossa. Dislocations by muscular action alone are rare, though they doubtless occur. They have been produced during convulsions and as the result of violent efforts, such as throwing a stone or a ball. In all probability the actual mechanism closely resembles that of dislocations from indirect violence, and, as in the latter group, the position of hyperabduction and external rotation have been present in a considerable proportion of cases, at the moment when the dislocation occurred.

Pathology of Dislocations.—The most common site of the rent in the capsule of the joint is upon its inner and lower aspect between the tendons of the long head of the triceps and that of the subscapularis muscle. Very rarely if the capsule is greatly relaxed dislocation may occur without any tear. Laceration of the tendons and muscles surrounding and attached to the joint capsule, notably the muscles passing from the scapula to the tuberosities, occurs as a part of the lesion, and may be more or less marked. Extensive rupture of these tendons plays an important part in the production of recurrent and habitual dislocations. In some cases the long tendon of the biceps is torn from its groove between the tuberosities and may be displaced in such a manner as to lie between the head of the bone and the glenoid cavity, or be twisted about the surgical neck of the humerus, thus constituting an obstacle to reduction. The subscapularis muscle may be more or less extensively torn, or the head of the bone may even penetrate the muscle. In some cases the lesser tuberosity is torn away from the head of the bone, and the same may be true of the greater

tuberosity. In other cases the anterior edge of the glenoid fossa is fractured. Since the use of the X-ray has become general in the diagnosis of injuries of bones and joints, these fractures have been observed with increasing frequency. Fracture of the upper end of the humerus as a complication of dislocations of the shoulder-joint is not very rare. Jones (*British Medical Journal*, June 16, 1906) reported two hundred cases of complicated dislocations of the shoulder in which the diagnosis was verified by the X-rays. Among these there were twenty-two fractures at the upper end of the humerus, sixteen of them fractures of the surgical neck. Other complications discovered were separation of the greater tuberosity; fracture through the anatomical neck including the tuberosities; fracture of the neck of the scapula, including the coracoid process; separation of the lesser tuberosity; fracture through the anatomical neck, and separation of a portion of the rim of the glenoid cavity.

The injuries of the blood-vessels and nerves complicating dislocations of the shoulder are described elsewhere. Stretching or partial rupture of the circumflex nerve, followed by temporary weakness of the deltoid muscle, is not uncommon. Total paralysis from rupture of the nerve is rare.

Symptoms and Diagnosis of Dislocations of the Shoulder.—While in general the diagnosis of dislocations of the shoulder is easy by ordinary methods of examination, yet such is not always the case, and if complicated by fracture of the upper end of the humerus, in the presence of great swelling, an accurate diagnosis may be difficult without the aid of the X-rays. In examining a dislocated shoulder it is desirable not only to discover the presence of the dislocation and the anatomical position of the head of the bone, but also to learn, if possible, in what position the limb was when the dislocation occurred, the character of the violence which produced it, and whether the head of the bone remains in the position which it first occupied, or whether it has assumed some new position as the result of manipulation. These data are often important in order that the surgeon may properly adapt his efforts at reduction to the anatomical peculiarities of the individual case. It is also important, as elsewhere pointed out, to examine carefully for evidences of injury to the nerve trunks of the axilla and to the blood-vessels, in order that, if such evidences are found, the patient's attention may be called to them, so that he will not attribute subsequent disability to the treatment which he received at the hands of the surgeon.

Here, as elsewhere, it is sometimes important, where any doubt exists as to the diagnosis, to compare the injury with the sound limb. For this purpose the patient should be stripped to the waist. In complicated cases, where the patient is very fat, or where much swelling exists, it may be necessary to give a general anesthetic. Although the signs and symptoms of all dislocations of the shoulder are more or less similar, it will be necesary to discuss the several varieties in detail. The common character of all is that *the head of the bone is absent from its normal position and can be felt and sometimes seen in some abnormal place.* We shall first describe the signs and symptoms of the most common form, namely, *subcoracoid.*

The patient sits or stands with his body inclined toward the injured side and supports his elbow with the uninjured hand. The shoulder is flattened. The tip of the acromion appears unduly prominent. The fullness of the deltoid muscle is diminished, instead of bulging outward, the line of the limb falls vertically downward, or nearly so, from the tip of the acromion to the deltoid insertion. The anterior fold of the axilla is displaced downward upon the injured side. The direction of the shaft of the humerus is changed and is

FIG. 88.—SUBCORACOID DISLOCATION OF THE SHOULDER.
(New York Hospital collection.)

directed from the elbow upward and inward to a point more internal than upon the uninjured side. The elbow is slightly abducted. Active movements of the upper arm are impossible. The arm can be passively abducted with ease. The hand cannot be placed upon the opposite shoulder. As the arm hangs at the side, slight measured shortening is usually present. The distance from the tip of the acromion to the external condyle of the humerus is slightly greater upon the injured side. If the arm is abducted, this apparent lengthening will disappear, and when fully abducted the injured limb will measure less than the sound one. Upon deep palpation over the deltoid, instead of the fullness created by the head of the humerus, a cavity will be felt. The head of the humerus is not in the glenoid cavity. Palpation in the axilla or beneath

the coracoid process will meet with a resistance which can be recognized by the fingers as a hard rounded body, the head of the bone. It may usually be identified positively as such by grasping the elbow and making slight rotary movements of the arm. The head of the bone will be felt to move also. The

FIG. 89.—SUBCORACOID DISLOCATION OF THE SHOULDER.
(New York Hospital collection.)

absence of the head of the bone from the glenoid cavity and its presence as detected by palpation below the clavicle and in the axilla are more readily perceived when the arm is abducted. The patient complains of spontaneous pain in the shoulder, made worse by passive movements. If the dislocation is incomplete and the head of the bone still rests upon the edge of the glenoid fossa, there will be less abduction of the arm, but the loss of function in the limb will be the same, and the pain is usually notably greater (Stimson). The fixation of the limb, or its passive mobility, depends upon the more or less extensive laceration of the capsule. If the capsule is extensively torn, passive mobility will be more free. As already stated, if there be a large bloody effusion around the joint, with great swelling, if the patient is very stout, or if the dislocation be complicated by fracture, the positive diagnosis, in case doubt exists, can best be made by stereoscopic X-ray pictures.

Intracoracoid or Subclavicular Dislocations.—This type of displacement is less frequent than the subcoracoid. The displacement resembles that just described, but is more marked, usually owing to a continuance of the force which produced the dislocation. The head of the bone occupies a position farther upward and inward. The dislocation is usually associated with extensive laceration of the subscapularis muscle. The greater tuberosity is often fractured. The head of the bone may occupy a position just beneath the clavicle and to the inner side of the coracoid process. The signs of dislocation, notably the flattening of the shoulder, are more marked than in the subcoracoid variety. Occasionally the head of the bone creates a visible prominence beneath the clavicle and to the inner side of the coracoid process. The elbow may lie close to the side of the body. The lower portion of the head and the neck of the bone only can be felt in the axilla. It is impossible to separate the head from the

FIG. 90.—POSTERIOR (SUBSPINOUS) DISLOCATION OF THE HUMERUS. Anterior view. (Kindness of Dr. P. R. Bolton.)

chest wall with the fingers. Abduction of the arm may be limited to a greater extent than in the subcoracoid variety. In rare cases the limb is fixed and abducted to the horizontal.

Subglenoid Dislocations.—The signs of this form, rare as compared with the anterior and internal types, resemble greatly those of subcoracoid dislocations. The flattening of the shoulder, the abduction of the limb, and the prominence of the acromion process, are all very marked. The diagnosis rests chiefly upon the easy palpation of the head of the bone in the axilla, below the glenoid cavity. If measured while the arm is moderately abducted, there will be apparent lengthening of the humerus upon the injured side.

Luxatio Erecta.—This very rare dislocation of the shoulder is charact by a downward displacement of the head of the humerus and by extren vation of the arm, which is persistent, so that the patient rests the fo upon the top of the head. The head of the bone lies in the axilla, belc glenoid fossa. The dislocation is produced by extreme elevation of the sometimes combined with external violence to the shoulder itself. The nosis would present no difficulty.

Posterior Dislocations.—Posterior dislocations are divided into two gro *subacromial* and *subspinous*. As compared with anterior dislocations, th rare injuries. The head of the bone may be made to tear the joint capsu

FIG. 91.—POSTERIOR DISLOCATION OF THE HUMERUS FROM THE SIDE.
(Kindness of Dr. P. R. Bolton.)

leave the glenoid fossa posteriorly by violent internal rotation of the arm, times combined with direct violence to the shoulder itself or to the elbow head of the bone lies behind the glenoid fossa in the subacromial variet beneath the spine of the scapula in the subspinous group. The sign symptoms of dislocation are far less marked in the anterior and internal so that in some cases without a careful examination the diagnosis mi missed. The arm is held close to the side usually, passive movements a tremely painful, active movements are abolished. It may be possible to ciate that the axis of the humerus points toward a place behind the g cavity. The acromion is prominent, and the coracoid process may also prominent in front. Palpation shows the absence of the head from the g

avity. The elbow is held a little forward and the arm is rotated inward. While the front of the shoulder appears flattened, posteriorly it appears unduly

FIG. 92.—POSTERIOR DISLOCATION OF THE HUMERUS FROM BEHIND.
(Kindness of Dr. P. R. Bolton.)

prominent, unless the position of the head of the bone is marked by superabundant fat or by swelling. The diagnosis depends upon finding the head

FIG. 93.—POSTERIOR DISLOCATION OF THE HUMERUS FROM ABOVE.
(Kindness of Dr. P. R. Bolton.)

of the bone displaced posteriorly beneath the acromion or the spine of the scapula, respectively. In cases of doubt the X-ray examination will determine the condition.

Upward Dislocations of the Humerus—Supraglenoid and Supracoracoid Dislocations.—In these very rare cases the head of the bone is displaced upward. In the cases in which the method of production of the dislocation has been known, it has usually been such that, as the result of a blow or a fall upon the elbow, the head of the bone was driven upward out of the articular cavity, so that it occupied a position between the acromion and the coracoid, or even projected to a still higher point. The muscles that are attached to the greater tuberosity of the humerus have been torn in several instances, and fracture of the coracoid is not an uncommon complication. The long tendon of the biceps is either ruptured or dislocated from the bicipital groove. Active motions at the shoulder are lost, and passive motions are restricted and very painful. The diagnosis depends upon the recognition of the head of the bone in its abnormal situation, between the acromion process and the coracoid, and should present no great difficulties.

Habitual Dislocations.—We have already spoken of those forms of dislocation of the humerus due to paralyses of the muscles about the shoulder-joint and to congenital defects. We refer now to that group of cases where a dislocation, having occurred as the result of traumatism and having been reduced, the dislocation recurs repeatedly, at irregular intervals, from very slight degrees of violence, frequently merely as the result of some unusual muscular effort of the arm, as in swimming, throwing a ball, etc. The tendency of dislocations of the shoulder to recur may depend upon rupture of the tendons of the spinati muscles at the time of the original injury, with an accompanying laceration of the capsule, or upon a fracture of the lip of the glenoid cavity. In some cases, where for the relief of the condition the head of the bone has been excised, loss of substance and deformity of the bone, due to bony absorption, has been observed.

These cases offer no diagnostic difficulties. The dislocation occurs from time to time from moderate or very slight degrees of violence. In some cases reduction is so easy that the patient is able to put the bone back himself. In others it is more difficult. The resulting interference with function will be slight or marked, according to the degrees of violence necessary to produce dislocation in the given case and to the occupation of the individual, which may be such that he is obliged to make such motions of the upper extremity as to reproduce the dislocation at frequent intervals. Various forms of treatment have been used, including excision of a portion of the capsule and excision of the head of the bone. In some cases the results of excision of a portion of the capsule are good. In others, if a fairly extensive operation is done, the results are not perfect; the dislocation does not recur, but the patient has some permanent limitation of motion at the shoulder-joint. When operating upon these cases it is better to do too little than too much.

Old Unreduced Dislocations of the Shoulder.—No fixed time can be given after which it is useless to attempt the reduction of dislocations of the shoulder. In some instances reduction has been found impossible after from five to ten weeks. If the dislocation remains unreduced as long as three or four months, reduction will be found either very difficult or impracticable. The recognition of ancient dislocations of the shoulder is usually not difficult. The history of the injury, the characteristic disability and deformity, render the recognition of the dislocation easier even than in recent cases in which the position of the head of the bone may be masked by swelling. After the dislocation has existed for a certain time, the glenoid cavity becomes more or less completely obliterated as a synovial sac, the cartilage becomes covered with connective tissue of new formation, the muscles become permanently shortened, and the bone forms for itself a more or less perfect articular surface in the parts upon which it rests. It should be borne in mind, in attempting to reduce ancient dislocations, that the dangers of serious injury to the blood-vessels, nerves, and the humerus are far greater than in recent cases. There is a strong temptation to apply undue violence or manipulations of a dangerous character. Open operation in recent years has been followed by favorable results in many instances. If insurmountable obstacles are found to reduction after exposure of the joint and the head of the bone through an incision, better results are obtained by resection of the head than after other forms of treatment.

CHAPTER VIII

DISEASES AND TUMORS OF THE SHOULDER AND VICINITY

DISEASES OF THE BURSÆ IN THE VICINITY OF THE SHOULDER-JOINT

Bursæ may develop in several situations in the vicinity of the shoulder-joint. Normally a bursa exists beneath the deltoid muscle, which occasionally communicates with the shoulder-joint.

The Supra-acromial Bursa.—A bursa is sometimes developed over the acromion as the result of occupations which involve the carrying of heavy weights upon the shoulder. Such a bursa, when formed, presents itself as a rounded, elastic, fluctuating, smooth swelling, and when not inflamed the skin is movable over it. The content of the bursa consists of watery fluid resembling thin synovia. If such a bursa becomes infected with pyogenic germs, it will be increased in size, tender and painful, and later on will give the signs of an ordinary abscess.

The Subdeltoid Bursa.—The subdeltoid bursa is of somewhat greater surgical interest. Inflammations of various kinds—serous, purulent, or tuberculous—are occasionally observed in this situation. The most superficial portion of the bursa presents posteriorly at the posterior border of the deltoid muscle below the shoulder-joint. Inflammations of the bursa may occur from traumatism, followed by an effusion of serum or of blood in the sac, or from infection. The characteristic signs present, when the bursa is distended by fluid, are an undue fullness beneath the deltoid muscle at its upper part, and an appreciation by palpation of the fluctuating circumscribed tumor. Fluctuation can be best appreciated by pressure upon the deltoid with one hand, while the fingers of the other are placed posteriorly at the most superficial point of the swelling. A differential point in diagnosis between inflammation of the bursa and inflammation involving the shoulder-joint is said to be that in the former pendulum-like movements of the arm may be made forward and backward without pain, whereas active abduction of the limb is painful.

The subdeltoid or subacromial bursa is a sac an inch and a half or more in width, which lies beneath the acromion process and the upper portion of the deltoid muscle above and to the outer side, and upon the supraspinatus muscle and the head and neck of the humerus below and to the inner side. In the normal position of the humerus a portion of the bursa projects beyond the top of the acromion and lies beneath the deltoid on the outer aspect of the shoul-

der. During elevation and abduction of the arm the bursa disappears for the most part beneath the acromion.

Inflammations of the Subdeltoid Bursa.—Inflammations of this bursa are of rather frequent occurrence, chiefly as the result of traumatism to the shoulder, and sometimes produce symptoms of a fairly definite character. The inflammations of this bursa have been especially studied by Kocher and by Codman, of Boston. The latter published a monograph on the subject which was read at the annual meeting of the Massachusetts Medical Society, June 9, 1908. Codman divides the nonsuppurative inflammations of the bursa into three types: (1) Acute or spasmodic type, (2) Subacute or adherent type, (3) Chronic or nonadherent type.

1. *Acute or Spasmodic Type.*—The symptoms of type one are localized tenderness on the point of the shoulder, just below the acromion process and to the outer side of the bicipital groove. In a small proportion of these cases this tender point may be made to disappear beneath the acromion when the arm is abducted, since the bursa is carried upward beneath the acromion and ceases to be palpable. Abduction and external rotation of the arm are painful and excite spasmodic fixation of the joint. Passive abduction and elevation of the arm can usually be made without pain or with slight pain. The pain is usually in the region of the deltoid and may extend down the arm to the hand. It is sometimes possible to appreciate the presence of effusion into the bursa by palpation.

2. *Subacute or Adherent Type.*—In this type adhesions exist between the bursal surfaces. There is marked limitation of active motion in the direction of abduction and external rotation. There may or may not be localized tenderness. If the effort is made to abduct the humerus passively, it will be found that only slight degrees of abduction can be made without the scapula taking part in the motion.

3. *Chronic or Nonadherent Type.*—There is no limitation of motion, but the motions of abduction and external rotation are painful. There may or may not be tenderness over the bursa. If tenderness is present, it will disappear in extreme abduction of the arm. The pain is made worse by use of the arm and may be severe enough to interfere with sleep.

In cases presenting the above symptoms, if fairly severe traumatism has preceded, it will always be wise to take X-ray pictures of the shoulder in order to eliminate fractures of the head of the humerus or avulsion of one or other of the tuberosities. It seems probable that many of the cases of so-called muscular rheumatism of the shoulder are in reality inflammations of the subdeltoid bursa, though others are doubtless a true though not severe neuritis. Beginning tuberculosis of the head of the humerus may closely simulate inflammation of the bursa. The diagnosis is to be made sometimes by the X-rays, in other cases only from the fact that tuberculosis is a progressive lesion and will be made worse instead of better by massage, passive motion or breaking up of supposed adhesions under an anesthetic.

Infections of the Subdeltoid Bursa.—Infection of the bursa with pyogenic organisms may occur as the result of open wounds, as a complication of septicemia and pyemia, or from the spread of a pyogenic process in the vicinity (osteomyelitis of the humerus or purulent infection of the shoulder-joint). The local signs of an acute inflammatory process will be present—pain, tenderness, swelling, and fluctuation. The character of the fluid can be readily determined by the introduction of an aspirating needle. In my own experience pyogenic infection of the subdeltoid bursa has not been a very rare localization for pyemic abscesses. The general symptoms of pyogenic infection are present.

Tuberculosis of the subdeltoid bursa is occasionally observed, and here, as elsewhere, it occurs in two forms. First, a very chronic form, with the production of tubercle tissue and of rice bodies within the bursa, showing but slight tendency toward caseation. In the second form the process is more acute and ends in the production of a tuberculous abscess. In either case the history is of a chronic swelling beneath the deltoid, giving the signs of an accumulation of fluid. If rice bodies are present, the sensation of friction may sometimes be appreciated on palpation. The diagnosis depends upon the signs and symptoms as above outlined, and upon excluding affections of the shoulder-joint and humerus.

DISEASES OF THE AXILLA

The Skin of the Axilla.—The skin of the axilla is one of the favorite sites of furuncle. The disease frequently occurs as a somewhat chronic complaint. One group of boils follows another during a period which may extend over several years, and that in spite of every form of antiseptic external application and of incision of the individual furuncles. In a recent case, which occurred in my service at the New York Hospital, a young woman had suffered from numerous furuncles occurring successively in both axillæ for a period of three years, in spite of careful treatment. My colleague, Dr. William A. Downes, excised a portion of the skin from each axilla, including the areas in which the furuncles had occurred. The treatment would appear to me to be a rational one under such conditions.

Pyogenic Infection of the Lymph Nodes of the Axilla.—Following infected wounds of the upper extremity, breast, and side of the thorax, pyogenic infection of the axillary lymph nodes is exceedingly common. One of the most frequent causes is pyogenic infection of trifling wounds of the fingers. Such infections were quite common among surgeons, nurses, and others who handled infected wounds, dressings, etc., before the days of the rubber glove. The wound or scratch upon the finger is followed by lymphangitis of the arm and by painful, tender swelling of the axillary lymph nodes. Usually the diagnosis of these cases offers no difficulties. The constitutional symptoms may be severe and the lymph nodes may swell to a considerable size in forty-eight hours. Wet antiseptic dressings and disinfection of the infected wound of the finger usually

result in improvement of the condition of the glands and subsidence of the constitutional symptoms. In other cases the lymph nodes become the seat of purulent softening, with the production of periadenitis and axillary abscess, or a series of abscesses. When purulent softening and invasion of the subcutaneous tissues of the axilla occur, there will be formed a tender, painful mass beneath the border of the pectoralis major, giving all the signs of acute pyogenic infection. Incision of the individual abscesses is sometimes followed by speedy cure,

FIG. 94.—TRAUMATIC ULCER OF THE AXILLA WITH CICATRICIAL CONTRACTION COMPRESSING THE AXILLARY VEIN CAUSING INTRACTABLE EDEMA OF THE ARM. (Bellevue Hospital, Out-Patient Department, kindness of Dr. J. C. Ayer.)

in other cases sinuses are left behind, and there may remain a mass of cicatrical tissue in the axilla containing chronic foci of suppuration, such that in some instances a dissection and removal of all the infected tissues may be necessary for cure. The wisdom of the total removal of the axillary lymph nodes early in the disease is questionable. It is probably safer and better to incise the individual abscesses, if it be found possible; or, if a large abscess result from periadenitis, to be satisfied with such an incision as will be necesary for free drainage.

Abscess of the axilla may occur as an extension from suppuration in the connective-tissue spaces of the neck. (See Neck.)

Tuberculosis of the Axillary Lymph Nodes.—While tuberculosis of the axillary lymph nodes is less frequent than is the case in the neck, still it is not very rare. It may occur as an isolated tuberculous lesion, but more commonly is associated with tuberculosis in other situations—the glands of the neck, the bronchial glands, the lungs, the joints, the bones. In the majority of cases coming under my own observation the patients have been individuals with extensive tuberculous infection in other parts of the body. The history of tuberculous glands of the axilla so closely resembles that of similar infections in the neck that the condition scarcely requires a separate description. The lymph nodes

of the axilla are, as elsewhere stated, the seat of secondary malignant growths, notably following primary carcinoma of the breast. (See Tumors of the Axilla.)

Aneurisms of the Axilla.—The axillary artery, beginning at the outer border of the first rib as a continuation of the subclavian, is deeply placed and extends as far as the lower border of the teres major muscle, where it becomes superficial and is continued as the brachial. At its commencement the artery lies below the brachial plexus of nerves; farther down it comes to be more or less surrounded by the cords of the plexus. The vein lies to the inner side of the artery. Aneurisms of the axillary artery may be traumatic or spontaneous. More than half of the cases belong to the former group. (See Injuries of the Axillary Vessels.) The spontaneous aneurisms occur as the result of degeneration of the arterial wall produced by syphilis, alcoholism, etc. They originate during middle life. They are notably more frequent in men than in women. The aneurism may arise from any portion of the vessel, but more commonly originates from either end than from the middle portion.

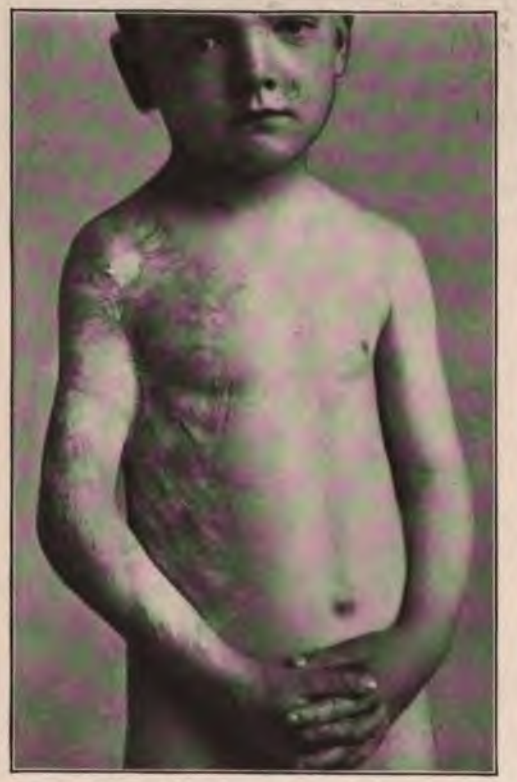

FIG. 95.—SCARS FOLLOWING BURNS OF THE AXILLA AND ARM, SHOWING ADHESIONS OF THE ARM TO THE CHEST WALL. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

Diagnosis of Axillary Aneurism.—The diagnosis of axillary aneurism depends upon the development of a tumor along the course of the artery, giving the signs of aneurism. In size and shape the sac varies considerably in different cases. It may be nearly spherical, ovoid or spindle-shaped, or more or less molded by the surrounding bones and soft parts. Its position varies according to the portion of the vessel from which it originates. If the aneurism arises from the first portion of the vessel beneath the clavicle, it will form a tumor in this region and cause a prominence of the pectoralis major muscle below the collar-bone. If it originates from the third portion, a tumor will be formed in the axilla, which may cause elevation of the shoulder and abduction of the arm. The most notable symptoms and signs other than the presence of a tumor giving the signs of aneurism, whose pulsations may be made to cease by pressure upon the subclavian artery, are pain, due to pressure upon the cords of the brachial

plexus; sometimes edema of the arm, due to pressure upon the axillary vein. If the tumor reaches a very large size, gangrene of the extremity has been known to occur. Aneurism of the axilla has been mistaken for abscess in a number of instances and may be confounded with very vascular pulsating sarcomata in the axilla. In the cases mistaken for inflammatory tumors the aneurism has usually been inflamed and the interior of the sac has been partly occupied by firm clots, so that the signs of aneurism were obscured or lost. The course of axillary aneurism is steadily progressive, ending in rupture and fatal hemorrhage if untreated. The tumor may cause erosion of the clavicle and ribs, with invasion of the thorax, or in other cases dislocation of the sternal end of the clavicle. Growth in an anterior direction causes bulging of the pectoralis major. A prominent tumor in the axilla is, however, a more common mode of growth.

Aneurisms of the Brachial Artery.—With the exception of aneurisms at the bend of the elbow, usually traumatic in origin, aneurismal dilatation of the brachial artery is exceedingly rare. Wherever developed, the superficial course of the vessel renders the diagnosis of aneurism very simple. In addition to the ordinary signs of aneurism, pressure upon the nerves, notably the median, may give rise to pain and paresthesiæ in the hand and forearm. The pressure symptoms are, when the aneurism is situated near the bend of the elbow, usually confined to the distribution of the median nerve. Arterio-venous aneurism in this situation will be mentioned when speaking of injuries in the vicinity of the elbow-joint.

TUMORS OF THE SHOULDER AND OF THE AXILLA

Every sort of benign and malignant tumor has been observed in these regions, and their diagnosis depends upon the same data, here as elsewhere. (See Tumors.) A few peculiarities only will here be mentioned. The shoulder is one of the most frequent sites for the development of lipoma. The tumor is, as a rule, subcutaneous in situation and offers no diagnostic difficulties. Lipoma may also occur in the axilla, where it will exhibit the ordinary characters of a slow and painless growth, distinctly encapsulated. If deeply placed beneath the pectoralis major muscle, the diagnosis may be less easy than when the tumor occupies a superficial situation. The history of a very slow growth and the consistence of the tumor, with absence of secondary nodules and metastases, are the data from which the diagnosis is to be made.

FIG. 96.—LIPOMA OF THE SHOULDER.
(New York Hospital collection, service of Dr. P. R. Bolton.)

The malignant tumors of the vicinity of the shoulder, developing in the soft parts, present no special diagnostic features. In the axilla the various forms of angioma are not very rare. Both the superficial nevi and the more deeply placed cavernous angiomata are occasionally observed. Their diagnosis offers no special difficulties. (See Tumors.) The lymphangiomata, both cavernous and cystic, are not infrequent in the axilla. In the cystic variety, either as the result of trauma or without a history of such, a sudden increase in size of the growth sometimes occurs as the result of hemorrhage into one of the cystic cavities. The sudden appearance of such a cystic tumor in the axilla should lead us to suspect the presence of a cystic lymphangioma. The diagnosis is to be made by the use of the aspirating needle and by the removal of the whole or a portion of the tumor.

The *malignant new growths of the axilla* arise more often from the regional lymph nodes than from other structures. They are in the majority of instances secondary tumors. In these cases the presence of the primary growth or a history of its removal usually renders the diagnosis of the axillary tumor entirely simple. In Hodgkin's disease the axilla is one of the situations in which the lymphatic tumors usually develop. The primary malignant growths of the axilla are more often sarcomata than other forms. They may grow from any of the mesoblastic structures, the bones, the muscles, the blood-vessels, the nerves; less commonly from the skin. They present the same characters as do sarcomata in other situations. The most notable symptoms after the tumor has reached a considerable size are pain from pressure upon the cords of the brachial plexus, and edema of the arm from pressure upon the axillary vein. Here, as elsewhere, epithelioma may occur in the skin and often develops as the result of chronic irritation, either from some chronic infection of the skin or upon the site of ancient scars. The diagnosis presents no difficulties. Much the most frequent malignant tumor of the axilla is carcinoma secondary to carcinoma of the breast. (See Tumors of the Breast.)

THE DISEASES AND TUMORS OF THE CLAVICLE

Acute Purulent Osteomyelitis of the Clavicle.—Acute osteomyelitis of the clavicle is scarcely observed as an isolated lesion. I have seen it occur in several cases of acute osteomyelitis with multiple localizations. In two of the cases observed the suppurative process involved not only the sternal portion of the shaft of the clavicle, but also the sterno-clavicular joint. In each case a pathological dislocation occurred.

Tuberculosis of the Clavicle.—Tuberculosis of the clavicle as an isolated lesion is uncommon. It is to be recognized here, as elsewhere, by the slow, painless, or only slightly painful, enlargement of the bone, by the formation of a tuberculous abscess following perforation of the periosteum. If the abscess is allowed to rupture, a sinus will remain leading to carious bone. The sterno-clavicular joint also may be primarily or secondarily involved. The signs and

symptoms will be those of tuberculosis of other joints, except that here pathological dislocation will often be observed. The outer portion of the clavicle and the acromio-clavicular joints are less frequently the seat of pyogenic and tuberculous infections than is the case with the inner end. The former may, however, occasionally be involved as a complication of tuberculosis of the shoulder-joint.

Syphilis of the Clavicle.—The inner half of the clavicle is not a very rare site for gummatous osteitis and periostitis. If the case is seen before softening and perforation of the skin have occurred, the slowly progressive enlargement of the bone will often be suggestive of malignant disease. In these cases the administration of mercury and of iodid of potassium in very large doses will cause diminution in the size of the bone, in some cases cure, in all, some improvement in the local conditions, so that by this means malignant disease may be excluded in the majority of instances.

Tumors of the Clavicle.—The clavicle is not a very frequent seat of either benign or malignant tumors. Osteoma and chondroma are occasionally observed in the clavicle, and in some of the reported cases the formation of the tumor has been preceded by injury to the bone. The malignant primary new growths of the clavicle are chiefly sarcomata which may originate either in the periosteum or in the cancellous tissue of the bone. They have been observed at all periods of life, even during infancy, and in these cases the tumor has usually been one of the soft and rapidly growing forms of sarcoma, the prognosis being very bad. The accompanying illustration is the picture of a man with sarcoma of the clavicle who was operated upon by Dr. Charles McBurney in 1898 at the Roosevelt Hospital. The tumor was of central origin and the clavicle was removed in part subperiosteally. The functional result in this case was excellent. As a matter of general experience it may be added that removal of the clavicle does not produce, as a rule, any marked disability.

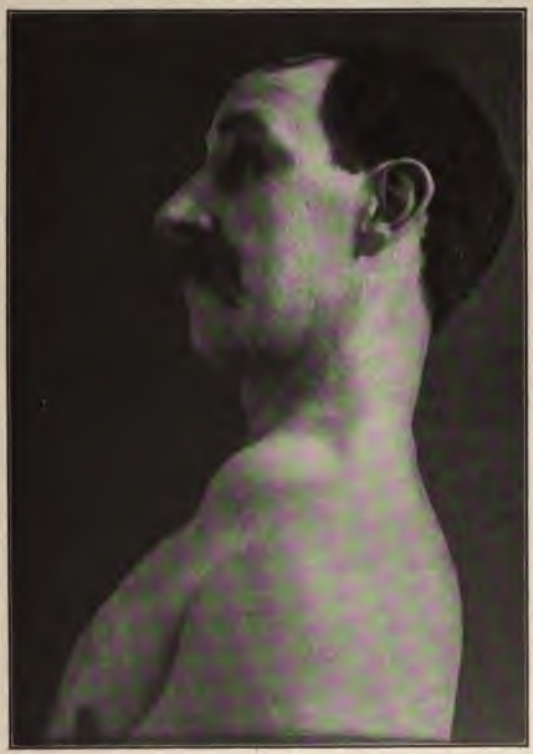

FIG. 97.—SARCOMA OF THE CLAVICLE SUCCESSFULLY REMOVED BY DR. CHARLES MCBURNEY AT THE ROOSEVELT HOSPITAL.

DISEASES OF THE SCAPULA

Acute Purulent Osteomyelitis of the Scapula.—Acute purulent osteomyelitis of the scapula is a surgical rarity. The bone may, however, become the seat of purulent infection as the result of open wounds, or as the result of the formation of bed-sores, notably in cases of fracture of the spine with crushing of the cord. In neither of these groups does the diagnosis of the condition offer any difficulties.

Tuberculosis.—Tuberculosis of the scapula, though rare, is occasionally observed. The acromion process, or the spine, or the portion in the vicinity of the glenoid cavity, are more often affected than the thin parts of the bone. When the disease occupies a portion of the bone in the vicinity of the shoulder-joint, secondary invasion of the joint is possible; or in other cases tuberculosis of the shoulder-joint may be followed by secondary invasion of the scapula. In the latter group infection occurs in the bottom of the glenoid cavity after destruction of its cartilage. In these cases the symptoms and signs will be those of disease of the shoulder-joint rather than of the scapula itself.

Tumors of the Scapula.—The various forms of benign growths are observed in the scapula. They include bony tumors, chondromata, fibromata, rarely other forms. The scapula is one of the situations in which the chondromata occur, of the type which produce metastatic tumors. In these cases degenerative changes in the growth are prone to take place, notably mucous degeneration, so that we have the combination myxo-chondroma. Combinations also occur with sarcoma and with carcinoma.

Malignant Tumors of the Scapula.—Of the malignant tumors of the scapula sarcoma is much the most common form. It is a disease rather of youth than of advanced life, but has been observed at all ages. The sarcomata may be of any type. They may be primary in the scapula, or secondary to sarcomata of the humerus, or of the soft parts of the thorax, or of the ribs. Here, as elsewhere, they vary much in rapidity of growth and malignancy according to the type of cells, etc. In a certain proportion of cases the appearance of the tumor has followed an injury to the bone. In some of these it appears probable that the tumor had existed for some time without attracting the attention of its possessor, and that as the result of the injury an accelerated growth has occurred.

Symptoms of Sarcoma of the Scapula.—The symptoms of sarcoma of the scapula are in no wise distinctive. In many cases a moderate dull pain will attract the patient's attention. If the tumor is in the vicinity of the shoulder-joint, or early infiltration of the surrounding muscles occurs, there may be some functional disability, a feeling of weakness, or inability to perform certain motions involving the use of the affected muscles. The more rapidly growing forms are often of such soft consistence that they may be mistaken for an inflammatory swelling, and this is more likely to be the case if, as sometimes happens, the patient has fever. When the tumor is superficially placed, or if

deeply placed, after it has involved the surrounding soft parts, it will form a visible and palpable mass attached to the bone. The early diagnosis of sarcoma of the scapula is highly important, since early operation, especially in the softer and more rapidly growing forms, offers the only possible hope of cure. Infiltration of the surrounding tissues and general dissemination through the veins occur in the more malignant types at an early period and render the prognosis very gloomy. The secondary tumors occur in the lungs, in the pleura, in the ribs, in the spine, and in the internal organs.

Treatment of Sarcoma of the Scapula.—The treatment of sarcoma of the scapula before it has invaded the shoulder-joint and the thoracic wall is removal of the entire bone. If the blood-vessels of the axilla, or the soft parts of the shoulder, or if the humerus is invaded, the removal of the entire upper extremity offers the only hope of cure. I operated some years ago upon a man who had a spindle-celled sarcoma of the scapula of not a very malignant type. There were two tumor masses. The larger one was about the size of an adult's fist. It occupied the spine near the acromion and a portion of the body of the bone. There was a second smaller tumor growing from the lower angle of the scapula. The case was treated by removal of the bone entire and of the attached muscles. The patient survived with a considerable disability of the arm. At the end of three years he was still well and free from recurrence. His home was in a rather distant city and I have not heard his ultimate fate. He was a man aged about forty-five years.

Prognosis.—The prognosis of sarcoma of the scapula unoperated is absolutely bad. In 1900 J. J. Buchanan published in the *Philadelphia Medical Journal a résumé* of the results of operations involving removal of the scapula. A large proportion of these operations was done for malignant disease, chiefly sarcoma. His conclusions at that time were as follows: The mortality of operations in which the entire upper extremity was removed, including the scapula, since the era of antiseptic surgery was 8 per cent.

Of the cases amputated for sarcoma and other malignant growths whose subsequent history was definitely known, 18.6 per cent remained well for three years or more.

Removal of the entire scapula for new growths gave a mortality of 7.3 per cent and 26 per cent of cures (to three years) in malignant cases.

Partial excision of the scapula for tumor taking away less than the entire body, showed an immediate mortality of 9 per cent and a record of 33.3 per cent of cures (to three years in malignant cases).

Partial excision of the scapula for tumor taking away the entire *body* or more, showed an immediate mortality of 26 per cent and a record of 6.25 per cent of cures (to three years in malignant cases). It is probable that early and complete removal of the bone would show a large percentage of cures.

INFLAMMATIONS OF THE SHOULDER-JOINT

For purposes of description the inflammations of the shoulder-joint may be divided into: (1) Acute noninfectious serous synovites. (2) Infectious inflammations of the shoulder-joint, which may be either acute or chronic. (3) Chronic inflammations of the shoulder-joint due to a variety of causes and presenting a group of lesions of the joint structures partly formative, partly destructive, which may be clinically divided into a number of types, according to the predominance of one or other group of lesions and which usually end in profound changes in the joint structures, resulting in marked diminution of function, sometimes in ankylosis, sometimes in the opposite extreme—namely, the production of a flaillike joint. (4) A fourth group, which, however, bears a certain resemblance to the chronic joint inflammations of group three, is constituted by the arthropathies of diseases of the spinal cord, locomotor ataxia and syringomyelia. (5) Hysterical affections.

Acute Noninfectious Serous Synovites.—Acute noninfectious serous synovites are caused by injuries, such as contusions of the shoulder, or by such injuries as cause ruptures of ligaments, including dislocations or fractures involving the joint, or ruptures of muscles in the vicinity of the joint. There will be the history of an injury, the joint will be painful, there will be marked limitation of motion. It seldom happens in the shoulder-joint, covered as it is by thick muscles, that the effusion produced by an acute traumatic synovitis is so marked as to be distinctly appreciable on palpation. If the effusion is considerable the arm will be held slightly abducted and rotated inward. It is to be borne in mind in examining the shoulder-joint that the scapula takes part in so many of the motions of the shoulder that unless the shoulder-blade be fixed, the examiner will often be misled as to the degree of mobility existing in the shoulder itself. A swelling which is visible and palpable posteriorly beneath the acromion process is more apt to be due to an effusion into the subdeltoid bursa than to effusion into the joint itself. Effusions into the shoulder joint proper can be better appreciated over the thinnest portion of the capsule—namely, to the front and to the inner side. It will be necessary in all but the slightest cases following injury to exclude fractures of the upper end of the humerus and fractures of the scapula. This can be best done in doubtful cases by means of the X-rays. In all these cases it is the duty of the surgeon to guard against the occurrence of permanent stiffness of the shoulder-joint. There is a strong tendency in these cases for the patient to carry the arm in a sling for too long a period. As soon as the symptoms of acute irritation of the joint have subsided, massage, douching with hot and cold water, and active motions made by the patient himself should be carried out in a systematic and careful manner. If the patient does not follow the direction of the surgeon on account of pain, or the fear of pain, gymnastics may be insisted upon, or in the more severe cases the adhesions must be broken up by the surgeon, either with or without an anesthetic, according to the fortitude of the patient or the

resiliency of the adhesions in the given case. These precautions are perhaps more important in regard to the shoulder than to any other joint, since patients soon learn to adapt themselves to a stiffened shoulder by utilizing the movements of the scapula. These, after a time, become very free, so that the limitation of motion at the shoulder-joint is not appreciated. If untreated, or improperly treated, the acute serous synovites of the shoulder-joint may become chronic, usually with the formation of adhesions and more or less permanent limitation of motion. In the shoulder the chronic serous synovites attended by distention of the capsule and stretching of the ligaments and increased mobility are rather rare.

Inflammations of the Shoulder-joint Due to Infections.—Under this head we may consider: (a) Inflammations due to open wounds and pyogenic infection of the joint. (*b*) Due to the extension of inflammatory processes from neighboring tissues, as from acute osteomyelitis of the humerus. (*c*) Infections of the joint in the course of acute systemic infections, pyemia, septicemia, gonorrhea, typhoid fever, pneumonia, and the infectious exanthemata. As a subdivision of this group may be added tuberculosis and syphilis. Further, the inflammations which occur in the course of acute articular rheumatism.

While the inflammations which occur as the result of pyogenic infection of an open wound of the joint are distinctly purulent, those which occur as a complication of osteomyelitis, of pyemia, septicemia, and acute infectious diseases of a specific character, may be followed by a joint inflammation in which the exudate is serous, sero-fibrinous, catarrhal (that is to say, serous with a variable admixture of leucocytes), or distinctly purulent.

Purulent Arthritis of the Shoulder-joint.—From whatever cause arising, the purulent inflammations of the shoulder-joint have many signs and symptoms in common. Locally, there are pain, swelling and edema of the overlying soft parts, and more or less marked effusion into the joint. There is total disability of the limb with complete loss of function at the shoulder-joint. Active motions of the joint are impossible and passive motions are attended by marked increase of pain. Usually the joint is immovably fixed by spasmodic muscular contraction in slight abduction and internal rotation.

The *constitutional symptoms* vary greatly in severity, according to the character of the micro-organisms concerned in the process and the severity of the local and constitutional poisoning. Infection of the shoulder-joint following open wounds is characterized by a distinctly purulent exudate with progressive symptoms of septic intoxication. The picture is that of a more or less severe septicemia. In *pyemic* cases, as elsewhere stated, the local signs and symptoms are usually far less marked. Moderate spontaneous pain, tenderness, loss of function, and marked pain on passive motion are present. In the worst cases, following open wounds or occurring in the course of pyemia, the joint structures may be very rapidly destroyed, so that after a few days, or a fortnight, passive movements of the joint may elicit bony grating from the destruction of the cartilages covering the articular surfaces. In the shoulder, as in

other joints, perforation of the capsule may occur, to be followed by purulent inflammation of the surrounding soft parts and burrowing of pus along the bicipital groove and beneath the deltoid muscle.

In any of the exudative inflammations of the shoulder-joint the character of the exudate and its bacterial content, whether pyogenic, typhoid, or other germ be concerned in the process, can best be indentified by the use of the aspirating needle introduced into the joint in front, between the acromion process and the head of the bone. If the exudate is not distinctly purulent but is of the catarrhal type (a cloudy synovia containing a moderate number of pus cells), incision of the joint and washing out its cavity with a weak solution of carbolic acid (1 to 100 to 1 to 200) is sometimes followed by a good functional result. In the more severe cases resection of the head of the bone, or sometimes, if the periarticular structures are also invaded, amputation at the shoulder-joint, offer the only hope of saving the patient's life.

Gonorrheal Inflammations of the Shoulder-joint.—The gonorrheal inflammations of the shoulder-joint may occur, usually during the later weeks of the disease, as a serous, sero-fibrinous, catarrhal, more rarely as a purulent arthritis. The symptoms are those of acute inflammation of the joint with more or less marked septic symptoms, according to the character of the infection, whether due to the gonococci merely or to associated pyogenic forms. In males the diagnosis, in the presence of a urethral discharge, a history of recent gonorrhea, or of purulent urine, offers no difficulties. In women the diagnosis may be more difficult. (See Gonorrheal Rheumatism.) In children, in institutions, gonorrheal joint inflammations, usually polyarticular and often of severe, even of a fatal, character, are observed, sporadically and in epidemics. A recognizable genital or other local origin of infection is often absent. Thus Holt reported 26 cases in the Babies' Hospital in New York City during 11 years; 19 were male children. In one only were there local evidences of gonorrheal infection. Fourteen cases were fatal. In all, the gonococci were found in the joint exudates.

A true purulent inflammation of the shoulder-joint rarely occurs. There is, however, in the shoulder a marked tendency for the disease to become chronic and to be followed by more or less firm ankylosis with corresponding disability. In my personal experience, the chronic gonorrheal joint inflammations often react violently when efforts are made to break up the adhesions under a general anesthetic. In the statistics of Northrup, Finger, Benecke, the shoulder-joint is in point of frequency the fifth joint affected in gonorrhea. It is to be borne in mind that not only may gonorrheal inflammations of the joints occur during acute gonorrhea, but also that such infections may arise at a very late period; so long as living gonococci still exist in the mucous membrane of the genito-urinary tract, or elsewhere in the body. In men it is exceedingly prone to relapse with the fresh outbreaks of urethral inflammation excited by alcoholism, etc. (See Gonorrhea.) It has been observed in children, male and female, and in infants as a complication of gonorrheal conjunctivitis. As stated

under Gonorrheal Rheumatism, Vol. I, the gonococci are occasionally found in the joint exudate, though in many cases the diagnosis must rest upon identification of the germ in the urine, or in smears from the mucous membrane of the genital or urinary discharges. (See also Chronic Disturbances of Joints.)

Typhoid Inflammation of the Shoulder-joint.—The arthritis complicating typhoid fever may involve one or many joints. The exudate may be serous, catarrhal, or distinctly purulent. The typhoid bacillus may be identified in the exudate from the joint in some cases, not in others. In a certain portion the fluid aspirated from the joint will be sterile. In those cases involving but one of the larger joints, the shoulder, the hip, or the knee, the character of the inflammation is more apt to be of an intense and destructive character than when many joints are involved. If the joint affections occur during the active period of the disease, the dull mental condition of the patient may be such that the joint lesion remains unrecognized, or is only discovered by accident. In the milder cases, little or no pain will be complained of unless the joint be moved, when the pain may be slight or severe. Actual suppuration with perforation of the capsule is rare, but ankylosis, or notable relaxation of the joint capsule, with atrophy of the muscles and more or less complete pathological dislocation, is fairly common, more common in the hip-joint than in the shoulder. Upon careful examination the recognition of the condition offers no difficulties. It is desirable to determine whether a true typhoid arthritis exists, or whether the joint lesion is simply a part of a complicating pyemia or septicemia. This is to be determined, as already indicated, by aspiration of the joint and identification of the organisms present in the exudate. The distinction is important from a therapeutic as well as from a prognostic point of view. Drainage or excision of the joint will be less commonly required when the typhoid bacillus is alone present than when one or other of the pyogenic organisms are found in the exudate.

Joint Inflammations Secondary to Osteomyelitis of the Humerus.—There are no distinctive peculiarities to be observed in the shoulder. The exudate may be serous and remain so, or first serous and then purulent, with more or less destruction of the bones and soft parts entering into the joint, or with separation of the epiphyseal cartilage. The involvement of the joint will, in many cases, be discovered only when operating upon the humerus itself. If the joint be merely the seat of an irritative process without actual invasion of the joint cavity by pyogenic germs, the prognosis as to functional result is good. If, on the other hand, the joint becomes the seat of a purulent arthritis the outlook is grave. (See Osteomyelitis, Vol. I.)

Joint Inflammations Complicating Pneumonia.—Pneumococcus invasion of the shoulder-joint during the course of pneumonia or after convalescence is a rather rare but very serious joint inflammation. The signs and symptoms are those of acute purulent infection of the joint. The diagnosis is to be made from the existence of pneumonia or from identification of the

pneumococcus in the joint exudate. Destruction of the joint, sometimes with extensive suppuration, and death from generalized infection, or in more favorable cases more or less complete ankylosis, is to be expected.

Acute Articular Rheumatism.—Acute articular rheumatism is usually a polyarticular infection attended by the signs of an acute synovitis of several joints, by periarticular swelling, by fever, often by sweating, and frequently complicated by endocarditis. The joint exudates are usually sterile and of a serous character. Several organisms have been identified in the exudates during the course of acute articular rheumatism. On the other hand, in many cases the effusions are sterile, so that while it is highly probable that acute articular rheumatism is an infectious disease, no single organism has been identified in all cases apparently typical, so that at present it cannot be said that the lesions observed in acute articular rheumatism constitute a pathological entity. (See Appendix for more recent views.)

Tuberculosis of the Shoulder-joint.—The shoulder-joint is less commonly the seat of tuberculous infection than is the case with the knee, the hip, and the elbow. The disease occurs most often between the fourteenth and the thirtieth year of life; and while tuberculosis of the knee- and hip-joints is common in children, tuberculosis of the shoulder is rather rare. The disease may occur in several forms. It may be primary in the synovial membrane, or secondary to tuberculosis of the epiphyseal end of the humerus, or to a tuberculous focus beneath the cartilaginous covering of the glenoid fossa of the scapula. (See Scapula.)

Although the pathological lesions of tuberculous arthritis of the shoulder possess no very distinctive characters, absent in tuberculous infections of other joints, yet some peculiarities may be here mentioned. A typical tuberculous hydrops with the formation of a large fluid exudate in the joint is uncommon. In the cases primary in the synovial membrane the process is usually diffuse from the beginning. In the early stages the entire surface of the synovial membrane is studded with tubercles of submiliary size. The formation of tuberculous granulation tissue follows; and such tissue gradually invades and takes the place of the cartilages covering the articular surfaces. Upon incision the semitranslucent gelatinous material bulges out through the opened capsule of the joint. There is a marked tendency in tuberculosis of the shoulder, whether primary in the synovial membrane, or in the bone, *to destruction and disappearance of the head of the humerus.* In late cases the head may be almost destroyed, so that the direction of the shaft of the bone resembles that observed in anterior dislocation of the humerus.

In the cases primary in the bone, a tuberculous focus is formed with the production of a small sequestrum. The joint becomes secondarily involved and presents the ordinary appearance of a *fungous arthritis* again with a tendency to bone absorption. In both forms perforation of the soft parts and the production of sinuses are not uncommon. In that form of the disease ordinarily known as *caries sicca* there is the formation of a rather small amount

of tuberculous granulation tissue within the joint, which gradually invades and destroys the cartilages and produces destruction and absorption of the head of the humerus, as already described. As originally designated, the process was supposed to go on to destruction of the head and complete ankylosis without the formation of sinuses. The latter are, however, observed in a fair proportion of cases.

Extensive infiltration and tuberculous disease of the shaft of the humerus is exceptional. In the typical cases of *caries sicca* the history and clinical signs and symptoms are somewhat as follows: The patient is usually a young adult. The first symptoms noticed are apt to be a feeling of weakness in the shoulder-joint, perhaps combined with slight stiffness and pain. The symptoms are often first observed when arising in the morning and may be less noticeable during the day. After a time, *pain* of a neuralgic character occurs in the shoulder, together with localized tenderness, most readily appreciated by palpation of the head of the bone in the axilla. The pain and stiffness of the joint increase. There is soon added *atrophy of the muscles of the upper arm and shoulder*, together with the muscles attached to the scapula. As a consequence the shoulder appears flattened, the acromion process more prominent, the deltoid undergoes very noticeable atrophy; instead of an appearance of swelling, all the tissues about the joint are shrunken.

Upon palpation, however, apparent thickening of the upper end of the bone, due to swelling and infiltration of the capsule and of the ligamentous structures of the joint, may be appreciated. As the absorption of the head of the humerus progresses, the loss of fullness beneath the acromion becomes more and more marked. The pain and stiffness of the joint increase and complete ankylosis usually occurs, in the unfavorable cases, in the course of one or two years. As elsewhere stated, such ankylosis is less noticeable in the shoulder-joint than in other situations, on account of the mobility of the scapula. The formation of *sinuses* is more common when the original focus has occupied the upper end of the humerus. In children the growth of the humerus and the development of the entire upper extremity are notably interfered with.

Tuberculosis of the shoulder-joint is rather frequently complicated by tuberculosis of the lungs or of other organs, though not as frequently as is the case with tuberculosis of the wrist. The prognosis for cure is naturally better when a tuberculous focus exists in the upper end of the humerus, which can be removed by operation before the shoulder-joint is involved. Such foci can occasionally be recognized with some degree of probability by finding a tender, painful point near the upper end of the bone. If a patient comes to us complaining of pain and stiffness in the shoulder without apparent cause, and such a tender point is found, the diagnosis of *tuberculous infection of the bone may usually be demonstrated by a carefully taken X-ray picture or pictures.* If the patient is a growing child, it is well for the friends to know that however favorable the outcome as regards cure may be, the growth of the humerus will probably be interfered with.

Syphilitic Inflammation of the Shoulder-joint.—As stated in Vol. I, under Syphilis, a number of forms of joint inflammation may occur during the course of the disease. In the earlier stages, such inflammations are of a serous or sero-fibrinous character, and get well under suitable treatment with perfect restoration of function. During the later tertiary stages more serious lesions may occur, either as a primary gummatous arthritis affecting the soft parts of the joint, or as localized gummata in the head of the bone, which rupture into the joint and cause a more or less active and destructive inflammation. Here, as elsewhere, there is a tendency toward a destructive and a productive lesion advancing side by side, resulting in marked deformity of the joint surfaces and a corresponding diminution of function. In many instances dense bands of fibrous tissue are formed within and around the joint, resulting in stiffness, which may amount in the end to complete ankylosis. In other cases the destructive process is more marked, the head of the bone may wholly or partly disappear with notable relaxation of the ligaments, ending in a flaillike joint or in a pathological dislocation. The disease is to be recognized by the pain, loss of function, and in the later stages by the deformity, occasionally by the formation of gummata, which soften and break down, forming abscesses in the vicinity of the joint, though the latter are rather rare; by the history of syphilis, by the very chronic course, and by the presence of syphilitic manifestations elsewhere in the body.

Chronic Disturbances of Joints Probably Noninfectious.[1]—Under this head may be grouped a number of chronic disturbances of joints, due to a variety of causes, presenting a variety of lesions, characterized by profound changes in the bones and soft parts entering into the joint, and by disturbances of function of a very pronounced character. These affections are, with very rare exceptions, not of a suppurative character. In some cases, however, they appear as sequelæ of joint inflammations, primarily of an infectious origin, but in which the infectious agent has disappeared. These joint lesions are not confined to the shoulder; indeed, certain other joints—namely, the knee, the hip, and the joints of the fingers—are more frequently involved. In order, however, to economize space and to avoid repetition, I shall describe these disturbances at this place, since the lesions produced are similar in all the joints. Certain special characters peculiar to individual joints will be mentioned under the diagnosis of diseases of regions other than the shoulder.

The *chronic joint disturbances* under consideration may occur at any period of life, and may affect one or many joints. They are more common during adult life than in childhood, and more common in old age than in either. Although the lesions produced may be divided into several types, yet, in the individual cases, we frequently find a number of pathological changes both in the bones and in the soft parts in varying combination and of varying intensity—

[1] In the preparation of this section I have been largely indebted to the work of Dr. E. H. Nichols of Boston.

In individual cases some of the lesions may be present while others are absent. Further, from a similar causation we may find in one case a single lesion, or group of lesions, markedly developed, while in another case the relative development of the individual lesions will be quite different. It often happens that the joint exhibits at first one set of pathological changes, and that, as time goes on, other lesions are added, so that in a single joint many of the changes to be described may exist simultaneously or successively.

The cases may be divided broadly into several types, although it is to be borne in mind that one type may merge into another and that, as stated, many

FIG. 98.—MYOSITIS OSSIFICANS OF THE MUSCLES PASSING FROM THE SCAPULA TO THE HUMERUS. Bony ankylosis of the shoulder joint. (Specimen in the Anatomical Laboratory of the College of Physicians and Surgeons, Columbia University.)

of the lesions may exist in combination in the same joint. For purposes of description the chronic arthritides may be grouped under: (1) Chronic Serous

Synovitis; (2) Chronic Papillary Synovitis; (3) Ulcerative Arthritis, involving especially the articular cartilages; (4) Obliterating Arthritis, ending in fibrous or bony ankylosis; (5) The Deforming or Productive type. This type of chronic joint disturbance is characterized by the formation of new bone and cartilage developed from the periosteum bordering the articulation, by bony absorption in other parts of the joint, by vascularization of the cartilages covering the articular surfaces, by the formation of fibrous or bony ankylosis over certain areas in the joint, by marked deformity, and other changes to be spoken of more in detail. This type of the disease corresponds to the affection ordinarily designated as *arthritis deformans; osteo-arthritis; rheumatoid arthritis; rheumatic gout; malum senile*, and numerous other designations.

(1) Chronic Serous Synovitis.—Chronic serous synovitis more often results from a persistent effusion into a joint following acute synovitis produced by a single trauma, or from repeated injuries of the joint of moderate severity, than from other causes. In a certain proportion of cases it is due to the presence in the joint of a loose portion of cartilage, as after a rupture of a meniscus in the knee-joint, or from the presence in the joint of a portion of loose cartilage, resulting from the chondrification of hypertrophied tags of synovial membrane in cases of papillary synovitis to be described, or from the presence of such hypertrophied masses of synovial membrane, without the formation of loose portions of cartilage. It may occur as an independent affection. (See Vol. I, Intermittent Hydrops of Joints.) In some cases the condition follows an acute synovitis of the joint, caused by some infectious process, notably gonorrhea, or the serous effusion may form merely a part of the lesion in one or other of the chronic arthritides to be described. One of the most common causes is trauma to the joint, untreated or improperly treated, such as a distortion of the knee with or without a rupture of ligaments, or of a meniscus, or repeated traumata of the knee such as occur to football players. These cases, after the acute symptoms of synovitis have subsided, will continue to have an effusion into the joint, notably the knee, which subsides, partly or wholly, after rest, massage, and other methods of treatment, but which recurs again as soon as the joint is used. These patients complain of a sense of weakness and instability in the joint. If the condition is due to a loose cartilage, there will often be a history of sudden spasmodic pain in the joint following exercise; further, *the joint may become locked in a position of partial flexion.* Further flexion of the joint and manipulation will free the floating body from its position between the articular surfaces, when the joint may again be used. Such an accident is often followed by an increased amount of pain and of serous effusion into the joint.

The *diagnosis* is to be made from the history and by finding the displaced meniscus, or floating body, on palpation. *The X-rays do not cast a visible shadow of cartilage.* The treatment of these cases is operative removal of the meniscus, or of the floating cartilage, occasionally fixation of the meniscus by

suture. If these cases are neglected, they may go on to develop one of the more serious and destructive lesions of the joint about to be described.

In cases of *tabes dorsalis*, chronic serous synovitis of the knee is not infrequently observed. On account of the ataxic gait, these individuals are subjected to frequent slight injuries, as from walking into pieces of furniture or from falls. They sometimes develop as a consequence a chronic serous synovitis of the knee-joint. I have such a case now under my care which will serve as a good example of the condition. For the past five years this man, who has a markedly ataxic gait, has suffered from a chronic serous synovitis of the knee-joint, which has persisted and grown slowly worse, in spite of various forms of treatment, including immobilization, massage, baking, aspiration of the joint, and finally washing the joint cavity with carbolic-acid solution. Following the various methods of treatment the effusion into the joint diminishes or disappears for a time, but as soon as the patient resumes the use of the joint, it again fills up with synovial fluid containing leucocytes and blood cells. The motions of the joint are free and painless, the ligaments are relaxed. At present, when the patient stands erect, the knee-joint assumes the position of hyperextension, more or less characteristic of these cases. There is no actual destruction of the joint surfaces, although such may develop in time. In other words, this is a typical Charcot's joint, though the lesion is not as yet a destructive one.

(2) Papillary Synovitis.—This may occur as the result of trauma to the joint and is usually combined with the preceding form—chronic serous synovitis. The lesion consists of an hypertrophy of the synovial membrane lining the joint. Exuberant folds and tags of synovial membrane project into the joint cavity, and as the result of mechanical insults, from pressure between the bony surfaces, an irritative condition is produced, which leads on the one hand to a chronic serous synovitis and on the other to a deposition of cartilage in plaques or in irregular masses, developed especially in the hypertrophied fringes of synovial membrane projecting from the sides of the joint. The masses of cartilage may be broken off from their attachments and form loose floating bodies, causing marked interference with the function of the joint, as described under Chronic Serous Synovitis. Such loose bodies are most commonly observed in the knee, less frequently in the elbow. The other joints more rarely show this type of lesion.

(3) Ulcerative Arthritis Involving Especially the Articular Cartilages.—This form is characterized by erosion of the cartilages and by the formation in consequence of circumscribed areas upon the articular extremities of the bones, where the cartilage is absent and where, as the result of pressure, the underlying bone becomes eburnated and undergoes more or less extensive absorption. The condition is followed by mechanical disturbances in the joint from the deformity of the articular ends of the bones, by profound disturbances of function, sometimes by marked deformity of the limb. As time goes on, the lesion is apt to eventuate in one or other of the more serious joint lesions about to be described. This form of arthritis may follow *serious*

injuries of the joint, such as *fractures involving the articular ends* of the bone, followed by deformity and destruction of the proper mechanical relations of the bones. The deformity may be due to actual malposition of the bony fragments, or to the *formation of new bone*, which projects into the joint, or in other cases the entire lesion will be caused by a fracture or other deformity of the bone, congenital or acquired, *in some part of the limb adjacent to the joint, so that the weight of the body falls upon the joint surfaces in an improper direction*, and thus a greater pressure is exerted upon one portion of the articular surface than it is designed to bear, while in another part the pressure is less than normal. Such a disturbed mechanical relationship is often associated with relaxation of the ligaments of the joint, and a chronic serous synovitis. The cases gradually merge into types four and five, to be described.

(4) Obliterating Arthritis, Sometimes Called Ankylosing Arthritis.—In these cases the lesion includes destruction of the cartilage by ulceration, as in group three, by fibrillation, softening and disappearance of the cartilaginous coverings of the bones. The place of the cartilages is taken by a vascular granulation tissue which spreads from the synovial membrane to the articular surfaces and gradually replaces them. This "synovial pannus," as it is called, advances, destroying the cartilage as it goes, until the space between the articular surfaces may be entirely obliterated. As time goes on this *soft vascular tissue* gives place to *dense, fibrous tissue*, and produces *fibrous ankylosis* of the joint. The obliteration of the joint cavity may be complete or partial. At a later stage the fibrous tissue may be converted into cartilage, and after a time into bone, producing a *true bony ankylosis.*

This form of the disease is common in adults, rare in children, and more common during young adult life and middle age than in the elderly. Generally the joint affection begins as an acute process.

It follows *gonorrhea* of the joints more often than other diseases, though it may be caused by trauma, or by any severe inflammation of the joint which stops short of actual suppuration. The process is thus, in a certain proportion of cases, infectious in its origin, although the lesions in the later stages are probably to be regarded as sequelæ, rather than due to the presence in the joint of the original infectious agent.

In children there occurs a form of polyarticular inflammation of joints, which sometimes exhibits this type of pathological lesion. The condition was originally described by Still and is often known as *Still's disease*, also as *arthritis deformans* of children. The disease has an acute onset. Many joints are involved. At first there is much periarticular thickening and swelling, with pain and tenderness. The condition is usually diagnosticated in its early stages as acute articular rheumatism. It occurs most often between the first and second dentitions. The acute symptoms subside, but are followed by ankylosis of one or many joints. The prognosis as to restoration of function in the affected joints is not good. The disease is frequently associated with very marked anemia, with enlargement of the lymph nodes throughout the body,

and with enlargement of the spleen. It may not always be easy to differentiate the affection from tuberculosis, except that in the latter, fewer joints are involved. There are no marked bony changes, such as can be identified with the X-rays.

(5) THE PRODUCTIVE OR DEFORMING TYPE OF CHRONIC ARTHRITIS.—This form is characterized by many of the lesions already described in the previous forms and with certain others in addition. There is destruction and vascularization of the surfaces normally covered by cartilage; there is a production of new bone along the edges of the articular surface and elsewhere, beneath the cartilage. In other portions of the joint the destruction of the cartilage is followed by atrophy and absorption of the underlying bone. The destructive and formative lesions advance side by side, so that the joint surfaces lose their normal contours and become quite irregular, thus interfering mechanically with the motions of the affected joint and producing marked deformities. In some of these cases portions of the synovial cavity remain and exhibit the lesions of chronic serous synovitis. In other parts the bone is denuded of cartilage, becomes covered with vascular tissue; this degenerates into fibrous tissue and forms a bond of firm union between the bones. This is especially noticeable, for example, in the knee-joint, where the patella often becomes firmly adherent to the condyles of the femur. As the result of bony destruction; in some cases combined with relaxation of the ligaments and muscular traction, dislocation of the joint, complete or partial, occurs, so that, whether the condition results in ankylosis or in a weakened and wobbly joint, the function of the affected joint is very seriously impaired or destroyed.

This condition may be characterized as *arthritis deformans* par excellence. It may follow a variety of causes. It is a disease most often noticed as a spontaneous condition in the elderly. In these cases it affects most commonly the knee, the hip-joint, the small joints of the fingers, and the joints of the spine. The last-named condition is described under Diseases of the Spinal Vertebræ (spondylitis deformans).

In addition to the spontaneous variety, arthritis deformans of this type occurs as a monarticular lesion, following injuries of joints of a severe character and fractures entering into joints, such that the mechanical functions of the joint are seriously impaired, so that abnormal strains and abnormal pressure are brought to bear upon the joint surfaces and upon the ligaments. One sees such joints as the result of badly united Pott's fractures. In several of the cases which have come under my observation the condition of the joint has been such as to render amputation or resection the only hopeful treatment.

When the disease is observed in the small joints of the fingers, as illustrated in Vol. I, page 169, the bony production at the ends of the phalanges leads to angular and other deformities of the fingers. These enlargements of the joints of the fingers are known as "Heberden's nodes." In the hip- and knee-joints the spontaneous form of the disease is characterized by very marked production of new bone. Osteophytes, sometimes of considerable size, form along the

edges of the articular surfaces of the femur, or tibia; or in the hip-joint, around the borders of the acetabulum. On account of continual pressure, the opposed bones in the articulation show corresponding pits and depressions; thus, the function of the affected joints is very seriously impaired or destroyed. In the course of *tabes dorsalis* and in *syringomyelia* identical conditions are often observed, resulting in the well-known Charcot's joint, but in these *the destructive part of the lesion*, less often the production of osteophytes, is greatly in excess of what is ordinarily observed in simple cases of arthritis deformans. Moreover, the progress of the lesion is far more rapid and is often accompanied by marked effusion into the joints, great relaxation of the ligaments, pathological dislocation, and sometimes by acute septic infection and suppuration of the joint structures. The last is, as a rule, a speedily fatal form of the disease, at least in my experience, if a large joint (the knee) is involved. The characters of these several lesions and the symptoms produced will again be mentioned when speaking of the different joints.

Diagnosis.—During the later stages of chronic inflammations of joints the diagnosis is not usually difficult. For example, a chronic affection of the hip-joint, or of the knee, in an old person is frequently associated with enlargement of the joints of the fingers, suggesting at once the character of the process. In the productive forms the irregular enlargements of the ends of the bones are easily recognized in an X-ray picture, and these characters may serve to distinguish the disease from tuberculosis. In the forms characterized by adhesions and fibrous ankylosis the diagnosis from tuberculosis may not be so easy at first. When the disease occurs in children it should be borne in mind that fever with accompanying inflammation of the joints may often be due to acute infectious osteomyelitis, and further, that acute articular rheumatism in young children is rare. When the disease follows a fracture into or near a joint with interference mechanically with the joint functions, the diagnosis does not, as a rule, present great difficulties. In the chronic serous forms some cause of continued irritation of the joint should be sought for—the presence of a floating cartilage, the history of an injury to the joint, and in the knee-joint especially, the locking of the joint during flexion by a fractured meniscus, or by the presence of a loose body.

Hysterical Affections of Joints.—The hysterical affections of joints have been discussed under the head of Traumatic Hysteria.

CHAPTER IX

INJURIES OF THE UPPER ARM

Owing to its exposed position, the upper arm is very frequently injured. The injuries may be grouped under *subcutaneous wounds*, including contusions, and *open wounds;* which again may be divided into incised, contused and lacerated, and gunshot wounds. We have discussed in another place the fractures of the shaft of the humerus. The recognition of contusions of the upper arm is attended by no marked diagnostic difficulties. Ecchymosis and the formation of hematomata are common, notably along the inner aspect of the arm where the tissues are rather loose. Effusions of blood beneath the skin do not, as a rule, produce circumscribed and tense swellings, but are more apt to be diffuse, so that the effused blood travels up and down the limb for a considerable distance. Thus, in fractures of the upper part of the humerus, we find these ecchymotic discolorations of the skin of the limb, which extends from the shoulder to the lower part of the forearm.

The open wounds of the upper arm may be incised wounds, or of the contused and lacerated type. The former occur from cuts with sharp instruments, knives, pieces of broken glass and the like. The skin and subcutaneous tissues merely, or the muscles, or the nerve trunks and blood-vessels, will be divided. The diagnosis of division of the muscles may be made by inspection; division of the blood-vessels will produce arterial or venous hemorrhage, as the case may be, easily recognized from the amount and character of the blood lost. Incised wounds of the nerves are to be recognized by the signs and symptoms already described in the section on Injuries of the Nerves. Contused and lacerated wounds of the upper arm may be slight, or, on the other hand, very grave injuries. In those produced by crushing violence, the humerus is frequently broken. In addition, there may be such extensive laceration of the soft parts, including the blood-vessels, that the question of amputation will often arise. Here, as elsewhere, the prognosis will depend largely upon whether or not the main artery of the limb is intact as evidenced by the presence of a radial pulse, and upon the amount of laceration and destruction of the soft parts of the limb in general. It should be borne in mind, as indicated in Vol. I, page 7, when speaking of contused and lacerated wounds, that contusion of an artery may eventuate in thrombosis of the vessel after hours or days, and that in these cases, for a time, pulsation at the wrist may be preserved. Much will also

depend upon the ability of the surgeon to render and keep such wounds aseptic. In some cases the task is easy, in some impossible. If the patient comes under observation very soon after the accident, the effort should be made to render the wound aseptic by vigorous scrubbing with soap and water and repeated douching with sterile salt solution. If the wound be soiled by dirt, grease, and other filth, turpentine and peroxid of hydrogen may be used to cleanse the raw surface. The greatest conservatism should be practiced and every effort made to save the limb. The development of fever, infection, cellulitis, leucocytosis, an odor of putrefaction and evidences of commencing gangrene, are indications for operative measures which must be varied to suit the conditions of the individual case.

Injuries of the Muscles of the Upper Arm.—Subcutaneous injuries of the muscles of the arm may occur from external violence, as from blows and falls, etc., or from muscular action. Degeneration of the muscle from any cause: inflammation, disuse, and chronic alcoholism favor the occurrence of such injuries. Muscular strains which rupture a few fibers only of a muscular belly are quite common. They arise most often as the result of violent muscular efforts, such as throwing a stone, attempting to lift a very heavy body, or some similar injury. These lesions are common in the upper extremity, in the back, and in the leg. They cause pain and some disability. They should be treated by firm support to the injured portion of the limb and not by prolonged rest. The use of the limb should be resumed early, though gradually.

Hernia of Muscles.—As the result of direct injury, muscular violence, or from disease, the fascial sheath of a muscle may be ruptured, and such a rupture may be followed by protrusion of a portion of the muscular belly through the rent in its sheath. Such muscular herniæ are rare. They have already been mentioned when describing Injuries of the Abdominal Wall. (See Vol. I.) The symptoms are sudden pain and a feeling of weakness in the extremity. The physical signs are, the protrusion of a portion of the muscular belly, which forms a prominent, soft, sessile tumor. While at rest, the tumor is readily recognized; when the muscle is passively extended the tumor disappears. When the muscle is put into moderate contraction the tumor diminishes in size. When strongly contracted against resistance the tumor disappears.

Ruptures of the Muscles of the Upper Arm by Muscular Action.—The biceps is more often ruptured in this way than other muscles. The long head of the biceps may be ruptured, less often the short head, occasionally the *tendon of the biceps*, before it is inserted into the radius, or the tendinous insertion itself may be torn away from the bone. The accident has usually occurred from violent and sudden muscular effort, and is followed at once by severe pain at the upper or the lower portion of the arm, according to the seat of rupture. There is immediate weakness in the power of flexing the forearm and in the power of supination. If the long head of the biceps is torn the shoulder tends to fall downward and forward, producing in some cases a slight partial

dislocation. Upon voluntary contraction of the muscle, a soft tumor appears representing the muscular belly. If the tendon of the biceps is torn away from its attachment to the radius, a sudden sharp pain will be felt on the front of the forearm and elbow, the power of flexing and supinating the forearm will be diminished. Usually a considerable tumor is formed on the front of the forearm above the elbow, which becomes harder and more prominent when the biceps is made to contract and moves upward toward the shoulder at the same time.

I operated some years ago upon a man who had received this injury while throwing a heavy shovelful of coal into a cart. He felt something snap in the region of the elbow, experienced a severe pain, and found himself unable any longer to use the shovel. The biceps formed a considerable tumor on the front of the forearm, and that, together with the disability, as above described, rendered the diagnosis easy. The lower end of the tendon was considerably frayed out. I drilled two small holes through the tuberosity of the radius and attached the tendon thereto by means of heavy catgut sutures. The elbow was dressed in a flexed position and the patient made a good recovery. There seemed to be no loss of power.

Ruptures of the Triceps, the *Coraco-brachialis*, and the *Brachialis Anticus* have occasionally been observed. The signs and symptoms are, the history of a violent muscular effort followed by a sudden severe pain in the ruptured muscle, diminution of function, sometimes the formation of a hematoma, the presence of a soft tumor which increases in size when suitable voluntary efforts are made, such as put the ruptured muscle into a state of contraction. The diagnosis of the anatomical site of the injury must be made from the character of the disability and the situation of the muscular tumor. In addition to the tumor formed by the contracted muscle a corresponding gap may be detected by palpation at the point of rupture, if it occurs through the muscular belly. If a large hematoma forms in the gap, its presence will be less noticeable.

If ruptures of tendons are untreated the disability is permanent. If ruptures of muscles are untreated a mass of scar tissue will be formed which may or may not permit some use of the muscle and will be palpable as a firm mass of scar tissue at the site of the rupture.

Injuries of the Blood-vessels of the Upper Arm.—The diagnosis of open wounds of the brachial artery can be made from the situation of the wound and the occurrence of active arterial bleeding. If the brachial is completely divided in an open wound, death from hemorrhage will occur very quickly unless surgical aid is at hand. If the vessel is merely punctured, here, as elsewhere, there may be formed an arterial hematoma, and this, if untreated, will increase in size, causing sometimes gangrene of the limb with diffuse infiltration of blood and swelling, or, in other cases, the tumor may finally rupture with fatal results. The occurrence of an *arteriovenous aneurism* has been observed, as elsewhere stated; chiefly following punctured wounds of the front of the arm near the elbow, but also, more rarely, between the elbow and the shoulder. The

signs and symptoms have been sufficiently described elsewhere, but in this situation very marked dilatation of the veins of the forearm and hand may develop, giving rise to functional disability of a high grade, together with the risk of accidental wounds of the dilated vessels. The symptoms of arteriovenous aneurism in this situation have been sufficiently described in Vol. I under the head of Aneurism.

Subcutaneous injuries of the upper arm may rupture the brachial artery. In other cases the violence will be such that the inner and middle coats of the vessel are torn with resulting thrombosis. The diagnosis is to be made in these cases from the situation of the injury and from the absence of pulsation at the wrist. A certain number of these cases proceed to gangrene of the hand or forearm. The more extensive the injury to the other soft parts of the limb the more likely it is that gangrene will occur.

Injuries of the Nerves of the Upper Arm and Forearm.—(See section on Injuries of Nerves.)

Gunshot Wounds of the Upper Arm.—In battle, gunshot wounds of the upper arm are not rare. They are frequently complicated by wounds of the thoracic viscera and abdomen. The characters of the wounds produced do not vary in this region from those occurring in similar tissues in other parts of the body. A few peculiarities only may be here noted. The modern military rifle bullet when fired at ordinary ranges produces, as a rule, comminuted fractures of the shaft of the humerus, with fissures running up and down the bone. In this way these wounds differ, as has already been noted, from fractures of the soft, spongy ends of the bone, where perforations with little or no comminution are fairly frequent. Certain differences have been noted in the effects of modern military bullets upon the shaft of the humerus, according to the range. At short ranges, while the bullet is traveling very rapidly, the humerus is broken and the surrounding portions of bone minutely comminuted. There are correspondingly serious injuries of the soft parts of the limb and a large wound of exit. At great ranges, on the other hand, the comminuted fragments are of larger size. There is less destruction of the soft parts and the wound of exit is apt to be smaller. Gunshot wounds of the soft parts of the limb merely present no special peculiarities which have not been mentioned elsewhere. (See Gunshot Wounds, Vol. I.)

Severe Contused, Lacerated Wounds of the Upper Arm, the Result of Blunt Violence.—In cities and in manufacturing centers severe crushing injuries of the upper arm are quite common. They occur from run-over accidents, by heavy wagons or trolley cars, from getting the hand or arm caught in moving belting, or in the grip of geared wheels; sometimes from boiler explosions, or explosions of gunpowder or dynamite. The character of the wounds produced vary in severity, from more or less complicated laceration of the soft parts of the limb, through compound dislocations and fractures with extensive crushing and stripping up of the skin, the subcutaneous tissues, and the muscles, to actual tearing away of the entire extremity from the body. Some of these injuries

have already been described in this chapter and in Vol. I, under the head of Contused and Lacerated Wounds, and some of them have been mentioned under the head of Diseases of Wounds in the same volume. A few additional remarks are here added.

The *diagnosis* of these injuries is usually not difficult. Frequently the condition of shock is well marked, and the surgeon will do well to confine himself at first to the control of hemorrhage by ligation of the vessels if there be bleeding, and to thorough cleansing of the wounds. The question of amputation can usually be decided without detriment to the patient by the delay, until after he has emerged from shock. In a certain proportion of these cases, though the hemorrhage may be stopped, the gravity of the injury is such that in spite of every effort the patient does not survive. In case of survival, the rules elsewhere laid down must be the guide as to treatment. In general it may be said that conservatism persevered in until the indications for amputation become plain is the wisest course. It is often surprising how well these complicated injuries may heal, even in the presence of fairly severe infection, and how useful such a limb may be after it is healed, though at first its usefulness appeared to be hopelessly destroyed. The surgeon may, however, err in the opposite direction, and persevere in his conservative measures until the patient is in a condition of general sepsis, when amputation will not save his life. Experience in these cases is the best and only guide in selecting the moment when amputation ought to be done. As has been elsewhere stated in this book, severe contused and lacerated wounds with destruction of large arteries may not bleed after the accident. The ends of the vessels may frequently be seen as twisted cords pulsating in the wound. Such vessels should, of course, be ligated, if possible, above the point of severe contusion, otherwise sloughing and secondary hemorrhage may occur at a later date.

CHAPTER X

DISEASES AND TUMORS OF THE UPPER ARM

THE SOFT PARTS

THE skin and subcutaneous tissues of the upper arm are, from the frequent injuries to which *the hand is exposed,* peculiarly likely to be the seat of both acute and chronic infectious processes. *Erysipelas* may extend upward from the hand and forearm, or downward from the head. *Lymphangitis.*—The arm forms a part of the avenue along which infectious processes of the fingers proceed to the axillary lymph nodes. The more violent and dangerous forms of septic poisoning are by no means rare in the upper arm. They follow infected wounds of the hand, the forearm, or the elbow. Sometimes the original wound is extensive, sometimes a mere pin prick. The course and prognosis of these acute infections vary here, as elsewhere, with the virulence of the inoculated microbes and with the powers of resistance of the patient. We see on the one hand the most violent infections recovered from (see case of phlegmonous inflammation of the arm and forearm from infection of the olecranon bursa, Vol. I, page 78), and on the other, fatal infections may occur from a trifling wound. As an illustration of the severity of a septic process, originating in a comparatively trifling injury, where the resisting powers of the patient were feeble and the infection severe, I may relate the following case which was under my care some years ago:

A stout and flabby woman, aged thirty years, entered the hospital with the following history: One week before, she had cut her left forearm on its outer surface, midway between the wrist and the elbow, with a broken bottle. The cut extended through the thickness of the skin merely, and was about an inch in length. She was seen by a physician, who placed one or more sutures in the wound and applied a dressing. Infection of the wound followed. She was brought to the hospital. Upon admission her left arm and forearm were greatly swollen; there was a wound as described. The stitches remained in place, and the surrounding tissues were under much tension. There was but little redness of the skin in the vicinity of the wound edges. Her temperature was 103° F., her pulse 125. She had a marked leucocytosis. Under anesthesia, incisions were made in the forearm. At this time, from the elbow to the wrist along the outer aspect of the limb, the subcutaneous tissues were in a state of purulent infiltration. The incisions were extended far beyond the limits of apparent infection; all tension was relieved; the patient's arm was enveloped in a dressing wet with acetate of aluminum solution,

five per cent, and the arm was suspended. The infectious process was not, however, controlled. At the end of three days the septic symptoms had grown steadily worse. The upper arm was swollen as far as the clavicle. Incisions showed that not only the subcutaneous tissues, but also the intermuscular planes of the upper arm were the seat of a partly suppurative, partly necrotic process, which extended as far as the top of the shoulder. Amputation at the shoulder-joint was followed by no improvement, and the patient died profoundly septic three days later. Media inoculated from the pus showed pure cultures of Staphylococcus pyogenes aureus. Other illustrative cases will be found in Vol. I, under Diseases of Wounds.

Lymphangitis of the Upper Arm.—In cases of lymphangitis extending up the arm from infections of the hand and fingers we often observe inflammatory enlargement of the cubital or epitrochlear lymph node, situated just above the internal condyle of the humerus. In many cases, after suitable treatment, the lymph node diminishes in size. In others, an abscess may occur at this point, and in still others localized foci of suppuration, subcutaneous in situation, may develop along the course of the lymph channels of the forearm and along the inner aspect of the upper arm, as far as the axilla. The red streaks upon the skin characteristic of lymphangitis are present in the earlier stages, and if abscesses are developed, they are readily recognized as red, tender, painful nodules beneath the skin, which sooner or later give the sign of fluctuation. In former years, the enlargement of the cubital lymph node was deemed of much significance in the diagnosis of early syphilis. While this gland may be, and usually is, enlarged during the active stages of the disease, this occurrence is by no means characteristic. In fact, any infectious inflammatory process of the hand or forearm may be attended by enlargement of this gland. Among laboring men, whose hands are continually subjected to traumatisms and slight degrees of infection, an enlargement of the epitrochlear gland of a chronic character is the rule rather than the exception, and, of course, in these cases bears no necessary relation to syphilis.

Olecranon Bursitis.—A frequent site for the beginning of acute infectious processes of the upper arm is the *bursa* commonly found over the olecranon process of the ulna. It is a bursa very often found enlarged among those whose occupations render it necessary for them to rest the point of the elbow upon some object while they are at work (stonecutters). The presence of the enlarged bursa is readily recognized as a smooth, rounded, tense, elastic swelling over the point of the elbow. When acutely infected it increases in size, becomes red, tender, and painful. If suppuration occurs the abscess formed may perforate the skin, or in other cases, as related on page 78, Vol. I, perforation takes place subcutaneously and may lead to a more or less violent infection of the arm.

Bony Growths in the Muscles of the Upper Arm.—Sometimes in the course of the disease known as myositis ossificans a bony deposit occurs in one or other of the muscles of the upper arm. The brachialis anticus appears to be a favorite site for such growths. In other instances small bony masses may occur as the result of repeated traumata to some muscle. Such is occasionally observed

among soldiers at the insertion of the deltoid. In other instances partial rupture of a muscle by a single trauma may result in the formation of a mass of scar tissue within the muscle, in which a subsequent deposit of earthy salts takes place, or later the formation of true bone.

Syphilis of Muscles (Gummatous Myositis).—The muscles of the upper arm, notably the biceps and the triceps, are not very infrequent sites for development of a gummatous myositis in the course of tertiary syphilis. The tumor masses thus formed may be diffuse and of very large size, or more circumscribed. They are usually very hard, and not infrequently attached to the bone. If developed in a muscular belly and not too deeply attached, they will be movable from side to side, but not in the length of the limb.

This form of gummatous infiltration has many times been mistaken for sarcoma, and surgeons have sacrificed limbs under these conditions, which might have been saved. The differential diagnosis from sarcoma should not be very difficult, if the case be kept under observation for a time. In case of doubt, the administration of mercury and large doses of iodid of potassium will be followed by marked improvement. Wasserman's reaction for syphilis may also be tried; and recent results would indicate that the judgments so obtained are fairly reliable. The occurrence of the Spirocheta pallida in tertiary syphilitic lesions is so hard to demonstrate, that the conclusions drawn cannot be at present regarded as entirely reliable.

Diffuse Syphilitic Myositis.—The muscles of the upper arm are some of the rarer sites of this affection; more commonly the masseters, the sterno-mastoid, and the muscles of the calf are involved. The affected muscle becomes painful, tender, rigid, and later contracted. If untreated, atrophy of the muscle with more or less marked contracture follows. The diagnosis depends upon the symptoms as above, upon a syphilitic history, and upon the beneficial results of specific treatment.

Pyogenic Infections of Muscles.—The muscles are rather infrequently invaded, either primarily or secondarily, by suppurative process. The occurrence of such infections is favored by general debility and by the diminished power of resistance which occurs as the result of acute infectious diseases. Infected wounds, notably of the contused and lacerated type, may be associated with localized abscesses or diffuse purulent infection of muscles. In the course of pyemia metastatic abscesses may occur in the muscles. (See Pyemia, Vol. I.)

Purulent arthritis with perforation of the joint capsule and invasion of the intermuscular planes may secondarily involve the muscles. The event is of bad omen. If a muscle forms part of the wall of an abscess cavity, its substance may be invaded, with the production of an abscess, or of necrotic or gangrenous infection.

Among those who are profoundly *debilitated from want of food and exposure*, a suppurative or gangrenous infection of the muscles with multiple localizations is sometimes observed. The disease is very commonly a fatal one. The muscles most often affected are the muscles of the leg and thigh, of the

upper arm and of the shoulder and chest. The patient becomes profoundly ill with great constitutional depression and the general symptoms of sepsis. Locally the affected muscles become painful, tender, and swollen. Their functions are abolished. Upon incision, abscess, necrosis, or gangrene of the affected muscles, circumscribed or diffuse, is observed. The patients quite commonly die before the lesions in the muscles are fully developed.

Under conditions similar to those described in the preceding paragraph, inflammations of the muscles in various parts of the body are sometimes observed, of an infectious character, not ending, however, in suppuration. The patients suffer from general debility and from pain and tenderness, with loss of function in the affected muscles. The overlying skin becomes edematous. There may be redness of the skin resembling erysipelas. In other cases there will be a macular eruption upon the skin. In the more severe cases there will be an elevation of temperature; in those which are less severe fever will be absent. In the cases which survive, the muscles become contracted and may undergo complete atrophy. The fatal cases usually die of a complicating broncho-pneumonia.

Tuberculosis of the Muscles.—Primary tuberculosis of muscles is a rare condition. It probably is never strictly primary; other foci of tuberculosis exist in the body. The affected muscles may be the seat of a diffuse submiliary or of a circumscribed tuberculous process. In a good many cases the disease has followed trauma to the muscles.[1]

The symptoms of the disease in its early stages are not very distinctive. Pain and diminution of function are not marked, unless the process is diffuse. When a cold abscess forms it will give the usual symptoms and signs. In some cases a slightly tender nodule may be felt in the muscle, movable from side to side when the muscle is at rest, but not in a direction parallel with the muscle fibers. The presence of other tuberculous lesions, absence of the evidences of syphilis, and the use of the aspirating needle established the diagnosis.

Secondary Tuberculous Invasion of Muscle.—Muscles may be invaded by the spread of tuberculous abscess from bones, joints, lymph nodes, or other foci. Abscesses, cicatricial contraction, or atrophy of the muscle may thus be produced. Such tuberculous inflammations of muscles are observed in the extremities, secondary to tuberculous arthritis and with some frequency also, in the *psoas* muscle as the result of tuberculous disease of the bodies of the spinal vertebræ.

Tumors of the Soft Parts of the Upper Arm.—The various forms of benign new growths are occasionally observed upon the skin or in the subcutaneous tissues of the upper arm—lipoma, fibroma, angioma, fibroneuroma, the last in the course of cutaneous nerves, occasionally other forms. The malignant

[1] Lanz and de Quervain (*Archiv für klin. Chir.*, xlvi, 97) made a careful study of the condition. The lesion of the muscles may result in atrophy, or in the formation of a localized tuberculous abscess.

epitheliomata may occur upon the upper arm at the sites of scars, chronic ulcerations, whether tuberculous or syphilitic, etc. They present the same characters here as elsewhere. The sarcomata are not especially frequent in the skin and subcutaneous tissues of the upper arm; they are more often observed in the muscles. The humerus, as will be noted later, is one of the favorite sites for the development of osteosarcoma. When sarcomata develop in the soft parts of the upper arm they exhibit the same characters as in other regions. They are not very likely to be confounded with any other form of new growth except the gummatous infiltration of the muscles already described.

The upper arm is occasionally the seat of *cirsoid aneurism*, although less often than the hand and forearm. The condition has been observed as a congenital condition, usually first in the hand or forearm, gradually spreading upward above the elbow.

THE NERVES

Diseases of the Nerves of the Upper Arm.—The injuries of the nerves of the upper arm have been described under Injuries of Nerves. As was there pointed out, these injuries may be followed by a neuritis beginning in the injured nerve and spreading upward to other nerve trunks, until many are involved. In addition to the traumatic cases, such neuritis may follow chronic alcoholism, poisoning by arsenic, and other metallic poisons, depressed states of health from any cause, or general infectious diseases, typhoid fever for example. Neuritis may also be due to exposure to cold and wet and to pressure upon the nerve trunks from tumors, aneurisms, displaced bones in cases of fracture or dislocation, or exuberant callus formation. The symptoms are, the sudden or gradual onset of pain of an annoying and distressing character, present both day and night, so that the patient is unable to sleep and is deprived of the use of the affected limb. The pain is greatly increased by motion, so that although the muscles may not be actually paralyzed at first, the patient is obliged to keep the limb quiet on account of pain. There is extreme tenderness over the course of the affected nerves. If the inflammation is severe, paralysis of the muscles supplied by the nerve trunks follows within a week of the onset of the symptoms, and in the course of a fortnight in bad cases the paralyzed muscles show the reaction of degeneration. In addition, there are subjective sensations of tingling and numbness. In severe cases there may follow disturbances in the nutrition of the limb with glossy skin, excessive sweating, interference with the growth of the nails, occasionally the development of herpes, sometimes of trophic ulcers. (See Injuries of Nerves.) When the neuritis is not due to an actual destructive lesion of the nerves, recovery takes place, but only after a long and tedious course—namely, after many months. When the neuritis is due to actual destruction of the nerve trunks, as described under Injuries of the Nerves, the prognosis is unfavorable and becomes worse the nearer the seat of injury is to the trunk. (See Injuries of the Brachial Plexus.)

Tumors of the Nerves of the Upper Extremity.—Neurofibroma, plexiform neuroma, and the so-called malignant neuroma, in which the nerve trunks undergo sarcomatous degeneration often in combination with myxoma, are all observed. The ordinary fibroneuromata developing in a peripheral nerve trunk have received the special name of "Tubercula Dolorosa." They are for the most part fibromata of the nerve sheaths, and the same is true of the plexiform neuromata, except that the lesion is in this case more diffuse.

The Circumscribed Fibroneuromata (Tubercula Dolorosa).—Circumscribed fibroneuromata occur in the course of the individual nerve trunks. They form small, fusiform or nodular swellings in the course of the nerve, more often in the subcutaneous than in the deeper nerve trunks, though they may occur in the median, ulnar, or other large nerves in the upper arm. They are more frequent, however, in the lower arm, wrist and hand. The sensory symptoms are more marked than the motor symptoms. Paralyses are rarely observed, but the patient suffers from spontaneous pain, referred to the seat of the tumor and to the distribution of the nerve, often combined with hyperesthesia, or abnormal sensations, such as tingling, heat, cold, formication. The fibroneuromata are frequently multiple. In the majority of instances the symptoms are not very severe, and indeed in some cases may be entirely absent. A tendency toward great increase in size is not marked. In the *malignant* types the nerve tumors take on a rapid growth. They tend to spread along the course of the nerve trunks and to form here and there considerable masses, sometimes as large as a hen's egg or a good-sized apple. The subjective symptoms of the malignant neuromata may be trifling for a long time. After the tumors have reached a certain size and have caused degeneration or destruction of the nerve fibers, the symptoms are practically identical with those just described under the head of Neuritis—namely, pain, paresthesiæ, diminution of sensibility, motor paresis or complete palsy, together with trophic disturbances of the entire extremity. The malignant neuromata originate more often in the *median* nerve than in other trunks.

The treatment of the benign neurofibromata of the arm will depend upon the severity of the symptoms and upon the particular nerve involved. If, as often happens, no symptoms are produced, the tumor may be let alone. If pain and other symptoms are prominent, and the tumor forms on a superficial nerve trunk whose functions are unimportant, it may be excised. If, however, an important nerve trunk is involved, the surgeon must bear in mind that, whereas some of these tumors are placed laterally upon the trunk of the nerve, or grow in such a manner that they simply force the nerve bundles apart, and may be readily removed without serious injury to the conducting power of the nerve, in other cases a dissection of the tumor from the nerve trunk itself is impossible. The situation then becomes much more serious, and in these cases it will be necessary to weigh the advantages of removing the tumor against the disadvantages of resection of the nerve followed by suture, and the possible permanent destruction of function. The only treatment for plexiform neuromata

and for malignant tumors of the nerves is extirpation. The operation will often be of necessity very extensive and the function of the nerves thus removed will be forever abolished.

THE BONES

Acute Osteomyelitis of the Humerus.—The signs and symptoms of acute osteomyelitis of the humerus do not differ materially from those observed in other bones. (See Acute Osteomyelitis, Chapter V, Vol. I, page 179.) The humerus is less commonly the seat of acute osteomyelitis than the femur or the tibia. The upper portion of the shaft is more often the site of the primary focus of infection than either the middle or lower part of the bone. The signs and symptoms resemble those already described in Vol. I. Severe septic poisoning is present, together with pain and loss of function in the arm, swelling and *extreme tenderness on pressure over the most intense area of infection.* If the process involves the epiphyseal cartilage, spontaneous separation of the head of the bone from the shaft may occur, and in the event of recovery the growth of the arm will be seriously interfered with. The arm will remain permanently shorter than its fellow. Infection of the shoulder-joint is less common than infection of either the hip or knee, when the disease occurs in the femur or tibia, respectively. In children, total necrosis of the shaft of the humerus is sometimes observed. Subacute and chronic osteomyelitis of the humerus is not very rare. (See page 183, Vol. I.)

Tuberculosis of the Shaft of the Humerus.—While the upper and lower ends of the humerus are frequent sites for the lodgment of tuberculous emboli and in these situations commonly precede tuberculosis of the shoulder and elbow-joint, respectively, *primary* tuberculosis of the shaft of the humerus is rare. When observed, it occurs as a distinctly circumscribed process, either in the cancellous tissue of the bone, or beneath the periosteum, or in other cases as a more diffuse tuberculous osteomyelitis. The latter group are, however, much more frequently due to an extension of tuberculous infection from near the ends of the bone. The diagnosis depends upon the formation of a slowly growing nodule, or a general enlargement of the shaft, in either case indicating infection of the periosteum, and upon the formation of a tuberculous abscess having the characters already described under Tuberculosis of Bone.

Syphilitic Infections of the Humerus.—Under Diseases of the Joints, Vol. I, we have already mentioned the inflammations of the epiphyseal ends of the humerus, which may occur in children the victims of hereditary or acquired syphilis. In the acquired syphilis of adults the humerus is not an uncommon site for the formation of localized gummata, or of diffuse gummatous osteitis of the shaft of the bone. The localized gummata in this region are not very rarely the cause of pathological fractures, or of fractures from very slight degrees of violence. Here, as elsewhere, the syphilitic process may be of a formative or destructive type, or both lesions may be combined. The diagnosis

is to be made by the formation of a slowly progressive, localized, or diffuse enlargement of the bone, by the presence of pain, worse at night, by obtaining a history of syphilis, and, where doubt exists as to the character of the process, by the administration of large doses of iodid of potassium and of mercury. The X-rays are often a valuable aid in these cases.

Tumors of the Humerus.—The humerus is rather a common site for the development of both benign and malignant tumors. Of the benign forms the bony and cartilaginous tumors are the most common, though some of the latter are malignant. Of the malignant new growths the various forms of sarcoma are observed with considerable frequency, carcinoma, only as an extension from carcinoma of the neighboring soft parts or as a metastatic growth.

The upper end of the humerus in the neighborhood of the epiphyseal cartilage is more commonly the point of origin of new growths of all kinds than are the middle or lower portions of the shaft.

Enchondroma.—Cartilaginous tumors are quite frequently observed, most often during youth and childhood, growing from the upper portion of the humerus. They are usually benign tumors which cease to become larger after their possessor has reached adult life. Their most common point of origin is at the junction of the shaft of the bone with its epiphysis—that is to say, from the epiphyseal cartilage. The tumors may reach the size of a pigeon's egg merely, or less commonly the size of an adult fist. They are readily recognized on palpation as hard tumors connected with the bone, painless and insensitive, with a smooth or knobby and uneven surface. The diagnosis of the exact character of the growth, whether of cartilage merely, or of cartilage and bone, can be accurately made by means of an X-ray picture.

In addition to the benign forms, there occur cartilaginous tumors connected with the humerus of a distinctly malignant character, with the production of metastases in other parts of the body. Some of these growths are purely cartilaginous, others are combinations of cartilage with myxomatous tissue, and in still others they are combinations with sarcoma, or are cartilaginous tumors which have undergone sarcomatous degeneration.

Exostoses.—Bony tumors may originate from the upper portion of the shaft, or from the upper epiphysis of the humerus. They may consist of bone merely, or in children and young adults they are frequently covered by a layer of hyaline cartilage. Their origin and mode of growth resemble that of the benign cartilaginous tumors, already mentioned. They are scarcely to be distinguished from the purely cartilaginous growths, except by the X-rays, or during an operation for their removal.

The *symptoms* produced by bony and cartilaginous tumors in this situation are due to their mechanical presence. They may interfere more or less with the movements of the upper arm, notably with abduction and rotation of the limb. If they press upon one or other of the cords arising from the brachial plexus, they will cause neuralgic pain or disturbances of sensation and motion in the parts supplied by the nerve trunk pressed upon.

Bone Cysts of the Humerus.—Cystic formations are occasionally observed connected with the humerus. They frequently follow injury and are usually developed beneath the periosteum. The contents of such cysts may be serous, blood-stained serum, or fluid blood. They originate in most cases from such an injury that the periosteum is elevated from the bone by an effusion of blood. The periosteum goes on to the production of a bony layer which finally comes to form a tumor, often of considerable size, sessile upon the bone. The shell of bone may be very thin so that it crackles on pressure, or quite thick. In December, 1908, I operated upon such a case in the New York Hospital.

The patient was a boy of sixteen, who had received a blow upon the front of the upper arm, about three inches above the elbow, one year before. A firm tumor had gradually formed at the seat of the injury, and when I saw the patient it had attained the size of half a mandarin orange. The chief symptom complained of was pain. The tumor was hard, sessile, and firmly attached to the humerus. Upon incision the mass proved to be a bone cyst containing about an ounce of bloody serum. The wall of the cyst was evidently composed of a thin shell of bone, which had developed from the periosteum. The surface of the humerus beneath the cyst was a little roughened, but otherwise normal. I removed the bony shell with a gauge and the patient made a prompt recovery. The pathological report showed that the tissues removed were of normal structure.

Echinococcus cyst of the humerus is an occasional localization. The diagnosis can only be made by the operative exposure of the cyst and the recognition of hooklets, etc.

Sarcoma of the Humerus.—By far the most frequent malignant growth observed in the humerus is sarcoma. The upper portion of the shaft of the bone is the favorite site for the development of these growths. The tumor may have its origin in the medulla of the bone, or from the periosteum. All the forms of sarcoma have been observed in the humerus. The disease may occur at any time of life, but is more frequently observed between the twentieth and fortieth years than at other ages. In a considerable proportion of cases the growth follows an injury to the bone, and yet it is difficult to allege with certainty that a direct causative relation has existed in many of these cases.

Though the sarcomata vary much in malignancy here, as elsewhere, it may be said in general that sarcoma of the humerus is a very fatal disease. The less malignant forms may occur and grow but slowly; they may for a long time remain inclosed within the bone, or beneath the periosteum. Under such circumstances amputation at the shoulder-joint, or even, *in rare cases, the mere removal of the infiltrated portion of bone may be followed by cure.* In others the local progress of the disease and its dissemination throughout the body are so rapid that by the time the diagnosis can be made with any degree of probability the patient is beyond hope.

The *periosteal sarcomata* are somewhat more malignant in certain cases than those having a central origin. The periosteal sarcomata usually grow from one

side of the bone, though in other cases the entire circumference of the shaft may soon be involved. A shell of bone frequently continues to surround the new growth for some time, and thus an ovoid or spindle-shaped enlargement of the humerus is produced of variable size, which may crackle on firm palpation. The *central sarcomata* may or may not produce expansion of the bone. In some cases such expansion will slowly or rapidly occur until a very large tumor exists, representing the shaft of the humerus. In these cases also, layers of new bone may be formed by the periosteum, or lamellæ of bone remain here and there throughout the substance of the tumor. These latter give very beautiful X-ray pictures. In other cases no enlargement of the bone occurs, but the infiltration of tumor tissue proceeds up and down the shaft. In this latter group the diagnosis of a tumor of the bone will often not be made until either a spontaneous fracture occurs at the seat of greatest destruction and absorption of bony tissue, or a fracture from some very trifling violence. The various *degenerative* and *retrogressive changes* take place in the sarcomata of the humerus, the formation of cystlike cavities filled with blood being the most common. Some of the *periosteal sarcomata* may be *extremely vascular* and may form *pulsating tumors.* This condition was formerly described, sometimes, as an aneurism of the bone.

After the growth has invaded the soft parts of the limb, the progress of the disease and the formation of a large tumor are usually extremely rapid. Such tumors may reach the size of an adult head, or even larger, before the life of the patient is destroyed. In the cases which are not operated upon, the overlying skin becomes stretched and shiny. Dilated veins may be seen upon its surface. Perforation of the skin and the formation of bleeding, fungating masses of soft sarcomatous tissue, frequently occur during the later stages of the disease. Death results from dissemination to distant organs—the lungs, the spine, etc.—or from hemorrhage, intoxication, and exhaustion.

Diagnosis of Sarcoma of the Humerus.—The early diagnosis of sarcoma of the humerus is not always easy. The patient may suffer from a dull pain in the upper part of the arm which may be diagnosticated as muscular rheumatism, neuralgia, or some other simple affection. In other cases a diagnosis of periostitis or of tuberculosis may be made. The diagnosis of an infectious process is the more likely to be made if, as in many of these cases, the patients develop fever early in the disease. If the shoulder-joint be early involved, the diagnosis of tuberculosis has often seemed probable. After the tumor has involved the soft parts and a rapidly growing enlargement of the upper arm takes place, the diagnosis will be simple, but will often be made too late. One of the most accurate means of making an early diagnosis is a carefully taken X-ray picture of the affected region. If bony enlargement or bony destruction be present, both will show with great clearness upon the photographic plate, and though the picture may not give positive knowledge of the exact character of the growth, yet the evidence so obtained will at least call for very serious consideration. In general, the rapidity of the progress of the disease will make the surgeon

suspect its malignant character. In several of the cases which have come under my observation, the patients having suffered merely from moderate pain in the upper arm, *the first signs of serious mischief have been spontaneous fractures of the humerus.*

Prognosis.—The prognosis of the less malignant forms of sarcoma of the humerus—notably of the encapsulated tumors originating in the periosteum—is not absolutely unfavorable. The treatment of this group of cases may even be conservative. In most instances, however, nothing short of amputation at the shoulder-joint, or in other cases of removal of the entire upper extremity, including the shoulder-blade and clavicle, will offer any hope of cure. In a good many cases, even with this very radical treatment, undertaken early, recurrence or dissemination and a speedily fatal result are to be expected.

Carcinoma of the Humerus.—Carcinoma of the humerus is observed only as a secondary or metastatic growth, due to dissemination of a carcinoma of some other part. In cases of carcinoma of the breast the humerus may be involved by direct extension, though this is rare, or as a metastatic process. Cancer of the humerus has been observed in a number of instances, secondary to carcinoma of the thyroid gland. The diagnosis usually presents no difficulties in the presence of a primary growth or of a history of its removal. The symptoms are a painful, rapidly progressive enlargement of the humerus, with secondary invasion of the surrounding soft parts by harder or softer cancerous tissue. In a considerable proportion of the cases the first symptom has been spontaneous fracture of the humerus.

CONGENITAL DEFECTS OF THE UPPER EXTREMITY

General Remarks on Congenital Defects.—While the congenital defects of the upper extremity present no serious diagnostic difficulties, most of them being easily recognized by inspection, yet the author believes that a few words in regard to them may not be out of place. The limbs of mammals are represented in the lower vertebrates, such as fishes by fins. The base of the fin contains a bone, from which proceed a number of rays. In fishes of a little higher order the rays may be arranged on either side of the limb. This early type of an extremity is modified in the Mammalia in such a manner that the extremity consists of four segments. The uppermost segment, upper arm or thigh, contains one bone, humerus or femur; the second segment contains two bones, radius and ulna, or tibia and fibula, respectively; the third segment contains the carpus or tarsus; and the fourth segment consists of the hand or of the foot, respectively. Embryologically, the several bones are represented by cartilaginous masses. If one or other of these cartilages fail to be produced, the limb eventually formed will be imperfect. If no cartilages are formed, representing the limb, there may be an absence of the entire extremity. Such a defect may involve all four extremities, in which case the individual is born with no extremities at all, or it may involve the upper or

lower extremities, so that no arms are produced, or but one arm; or no legs are produced, or but one leg. In the upper extremity the defect may involve the entire limb, or the humerus, or one of the bones of the forearm, more often the radius than the ulna, or the bones of the hand may be deficient. In some cases, merely a small stump ending in an imperfectly developed hand will represent the arm, in which may be preserved some small amount of function. These defects may occur in any combination. Their diagnosis presents no difficulties,

FIG. 99.—CONGENITAL DEFORMITY OF THE HAND. (New York Hospital collection.)

FIG. 100.—CONGENITAL DEFORMITY OF THE THUMB. (New York Hospital collection.)

as a rule, on inspection or palpation. After the bones have received an earthy deposit and have become true bones, the nature of the defect can be very clearly shown by X-ray pictures.

When a greater number of cartilaginous masses are formed than is normal, there may be a multiplication of the extremities; such multiplication may involve the entire limb, producing an extra leg, or arm, or only a portion of a limb. In the upper extremity the most common of these latter defects consists in the production of supernumerary digits, involving the fifth finger or the thumb more often than the other fingers. (See Fig. 100.) Another type of defect very common in the hand is the fusion of one or more of the fingers

together. Such fusion may involve the bones or the soft parts merely. When the soft parts only are involved, the condition produced may be that of "webbed" fingers. Whether this last condition represents reversion toward a former type I believe is not definitely known, but such may well be the case.

Infants may be born with imperfect extremities, due to another cause—namely, by constriction from amniotic bands, or possibly also by constriction produced by the umbilical cord. Such bands may cause the child to be born with complete amputation of an extremity, or, on the other hand, the constriction may be only partial, in which case the function of the distal part of the limb will be more or less seriously interfered with. Other congenital deformities may result in dislocations. These may occur at the elbow of one or both bones. The dislocation is more often backward than forward, and the radius is affected alone more often than the ulna. Sometimes the deformity is bilateral. In these cases the articular surface of the humerus may be imperfect, or the head of the radius may be malformed.

FIG. 101.—CONGENITAL DEFORMITY OF THE THUMB, PALMAR ASPECT. (Case of F. W. Murray.)

Congenital Cubitus Varus and Valgus.—Normally, in extension, the forearm deviates radially from the axis of the humerus and the position of the extended forearm, as referred to the humerus, constitutes what is known as "the carrying function" of the arm. Normally, this position of valgus is more marked in women than in men. In the latter, the deviation amounts to between one and nine degrees. In women, on the other hand, apparently on account of their narrower shoulders and broad hips, the deviation amounts to from twenty to twenty-five degrees (Hübscher). The full development of the normal cubitus valgus is not attained until adult life. Cubitus varus as the result of fractures of the lower end of the humerus will be spoken of under Injuries of the Elbow. If, during intra-uterine life, one of the condyles of the humerus

undergoes ossification sooner than the other, a condition of cubitus varus or valgus may be produced at birth or during infancy, so that the arm will deviate toward or away from the median line of the body respectively. A congenital cubitus varus has also been observed associated with relaxation of the lateral ligaments of the elbow-joint. It is very rare that these congenital anomalies require surgical treatment.

Congenital Defects of the Forearm.—Imperfect development or entire absence of the radius is much more frequent than of the ulna. The deformity is not rarely bilateral. Associated with the defect of the radius may be absence of the muscles upon the radial side of the forearm, notably those for the thumb and the supinators. Absence of the tendon of the long head of the biceps also has been observed in combination with imperfect development of the radius.

The radius may be present, but imperfect. In this group of cases the lower end of the bone is usually defective. The hand deviates markedly toward the radial side of the forearm and the muscles of the thumb are frequently imperfectly developed. The ulna is less frequently the site of congenital defects

Fig. 102.—Congenital Deformity of the Thumb. (Case of Dr. F. W. Murray.)

than the radius. When such occur, the deformity of the hand and forearm thus produced will be the opposite of that described—namely, the hand and wrist will deviate toward the ulnar side. The diagnosis of these conditions can, as already stated, usually be made upon inspection. The exact conditions of the bones are easily displayed by means of X-ray pictures.

In certain cases of congenital deformity of both the upper and lower extremities there is an increased growth, an *hypertrophy* which may involve the

entire extremity or only a part thereof. In the case of the upper extremity, such hypertrophies more frequently affect the fingers than the remainder of

FIG. 103.—CASE OF CONGENITAL DEFICIENT DEVELOPMENT OF THE FLEXOR MUSCLES OF THE FINGERS WITH APPARENT CONTRACTURE. The hands shown are at greatest possible extension. (Case of the late Dr. W. Vought.)

the limb. In certain cases the limb is simply increased in size, and the deformed limb in its growth keeps pace merely with the general growth of the body. In another group of cases, however, the hypertrophy involves especially the blood-vessels. In these the growth of the vessels and of the entire limb may be so rapid as to constitute an annoying and even dangerous condition, requiring surgical relief by amputation or other operation. In some of these cases the hypertrophy affects other structures—namely, the subcutaneous tissues, the lymphatic vessels, or the veins. The conditions thus produced invade the borderland of the several forms of new growth, affecting these structures, already described under Tumors. The treatment of all these conditions, if treatment is called for, is operative.

FIG. 104.—CLUBBED FINGERS. The result of a congenital defect of the heart. Patent foramen ovale. (New York Hospital collection. Medical service.)

Congenital Defects of the Hand.—The most common congenital deformities of the hand are those affecting the fingers. The fingers may be increased or diminished in number or in size; there may be fusion between two or several fingers, or one or several fingers may be imperfect or deformed. The commonest of these deformities is an increase in the number of fingers. The formation of two complete hands is exceedingly rare. Increase in the number of fingers is usually confined to the finger proper and more rarely involves the metacarpal bones as well. The multiplication is more common upon the fifth finger and the thumb. The most common type is the formation of two end phalanges. Both phalanges may articulate with the first phalanx, or the supernumerary phalanx may simply lie subcutaneously, without any articulation. In some cases the two phalanges are united by soft parts as far as the tip, in others they are more or less forked. (See Figs. 100, 101, and 102.) The number of additional fingers may be increased to five.

Abnormal fusion of the soft parts between the fingers may be so complete that the hand is webbed nearly to the finger tips; in other cases the fingers are forked to an abnormal degree, so that the hand comes to resemble the claw of a crab. The thumb and the fifth finger may be highly developed, while the remaining fingers are wanting, or in other cases the thumb and little finger are normal, while the remaining digits are fused into a single massive finger. Inasmuch as these deformities of the hand do not appear to depend upon any definite embryological data and cannot be interpreted upon genetic grounds, and since their recognition is extremely simple upon inspection, they possess no great diagnostic interest. As has been already noted, defects of the radius or ulna, respectively, may lead to marked deformity in the position of the hand. If the radius is absent, the hand will assume a position nearly at right angles to the long axis of the limb and toward the radial side. If the ulna is absent, the opposite deformity will be observed.

CHAPTER XI

INJURIES IN THE VICINITY OF THE ELBOW

CONTUSIONS AND SPRAINS OF THE ELBOW

Contusions in the vicinity of the elbow, which do not involve the bones, the nerves, the important blood-vessels, or the ligaments uniting the bones, possess no peculiar diagnostic interest, but it is to be observed that, since the use of the X-rays became general, fractures of the bones in the vicinity of the elbow-joint have come to be recognized in many cases, which formerly would have been regarded as severe contusions, or sprains merely. This is more particularly true, perhaps, of the radius than of the other bones. While fractures of the neck of the radius without impaction of the fragments are readily recognized on suitable palpation and manipulation, such is not the case when small fragments of the head of the bone merely are broken off, nor in the rather numerous group of cases in which a fracture takes place through the head of the bone, without separation of the fragments. The same may be said, to a lesser degree, of fractures of the coronoid process of the ulna. Accordingly, when examining an injury of the elbow-joint, which seems to be a mere contusion, or a sprain, it is desirable, when the injury is attended by much pain, swelling and local tenderness, to exclude the presence of fracture by means of X-ray pictures. As has already been many times stated in this book, *the fluoroscope is practically useless* for the diagnosis of these injuries.

Sprains of the elbow, or distortions, as they are sometimes called, are produced by various kinds and degrees of violence, such that, if continued, dislocations of the joint would occur. Thus hyperextension of the elbow will produce laceration of the front portion of the capsular ligaments, and if the violence be continued, a posterior dislocation of the radius and ulna. In the same way adduction and abduction will put the lateral ligaments of the joint upon the stretch and, if the violence be continued, produce dislocation or fracture. As the result of such injuries, the elbow is painful; there will be limitation of motion, and the pain will be increased when such passive motions are made of the limb as put the already partly ruptured ligaments further upon the stretch. If the ligaments are largely torn, passive motion may show the presence of an abnormal degree of mobility in one or other direction, indicating that the ligamentous structures have been weakened. The joint will exhibit a greater or less degree of swelling. In some cases there may be ecchymosis, and the formation of a more or less diffuse hematoma around the joint. The signs just

mentioned of relaxation or weakening of the ligamentous structures are not as commonly observed in the elbow as in the knee. Failure to find evidences of such weakness does not exclude the presence of some laceration of the ligaments of the joint. Under these conditions, if the limb be swollen, it may be extremely difficult to exclude the presence of fracture, and under such circumstances it is desirable to confirm the positive or negative diagnosis by means of a careful X-ray examination. In forming a prognosis in sprains of the elbow-joint, it should be borne in mind that the after results are not always perfect. This will be especially true in elderly individuals among whom a certain amount of stiffness of the elbow may long persist, or may in exceptional cases be permanent.

FRACTURES IN THE VICINITY OF THE ELBOW-JOINT

From a diagnostic point of view, fractures of the bones entering into the elbow-joint have always possessed an especial interest for surgeons. The recognition of the exact nature of the injury to the bones and the character and extent of the displacements in cases of fracture may be easy by ordinary methods of examination, or, on the other hand, exceedingly difficult. The recognition of the lesions and their correction are very important from a prognostic point of view. The elbow is a very important joint and uncorrected displacements of the bones forming it often result in marked disability, and for certain occupations, in serious incapacity. The diagnosis then of these injuries assumes a peculiar interest. It is true that at the present time the nature of the injury, the character of the displacement, etc., can all be recognized and demonstrated by the use of the X-rays in a manner formerly impossible. The indications for treatment may thus be made much clearer than was possible before we possessed this means of accurate diagnosis. By inspection and palpation alone it is often extremely difficult, or even impossible in the presence of marked swelling, to recognize with certainty the character of a fracture near the elbow-joint, and in some cases to detect the presence of a fracture at all. The exact nature of the displacements may also be hard to make out, and, further, the questions of whether such displacements have been reduced and whether the retentive apparatus has kept them reduced, may be difficult or impossible to answer by ordinary means. The X-rays answer all these questions clearly, and are indeed an invaluable aid in diagnosis. It, nevertheless, behooves the surgeon to be thoroughly familiar with the normal anatomy of the elbow-joint and with the signs and symptoms of the various types of fracture which occur in this vicinity. The X-rays are not always at hand.

In examining injuries of the elbow the caution already given elsewhere applies with peculiar force—namely, that in every instance the relations of the bony points in the vicinity of the elbow-joint should be studied, both upon the injured and upon the sound limb, so that the two can be compared. The four bony landmarks whose relations are important are the epicondyles of the

and internal; the tip of the olecranon process of the ulna, ie radius. The epicondyles of the humerus and the tip of the e apices of the angles of an equilateral triangle when the arm ht angle. When the arm is extended, these points lie in a ie head of the radius lies below the external condyle in the rist and separated from the condyle by a distance of from one ters of an inch. By placing the thumb upon the head of the g motions of pronation and supination at the wrist, the out- f the radius as it rotates beneath the thumb and its continuity the bone may be determined. In examining the elbow also, deviation of the axis of the forearm during extension as com- is of the humerus should be borne in mind. In examining f the elbow-joint, notably in children, among whom they are will be often necessary to give a general anesthetic.

ost important injuries in the vicinity of the elbow-joints are ie lower end of the humerus. For purposes of description, it roup these fractures under the heads of:

Above the Condyles at the Junction of the Shaft with the Bone, Supracondyloid Fractures.—The fracture passes across art of the humerus transversely, or obliquely, and the line of ay not open into the elbow-joint.

of the Internal Condyle.—In these the line of fracture runs border of the bone through the condyloid ridge downward and the joint somewhere upon the articular surface for the ulna ternal to it.

of the External Condyle.—The line of fracture begins upon on f the bone and extends downward and inward to the articular lar

of the External Epicondyle.—The fracture consists of the he minute portion of bone above the external condyle, the line ne sing into the joint.

the Internal Epicondyle.—The line of fracture passes some- e base of the internal epicondyle, and is extra-articular.

oid, the so-called T and Y Fractures.—The fracture involves s condyles, frequently with comminution of the lower end of f ry is usually very severe and due to great degrees of violence.

of the Lower Epiphysis of the Humerus.—The line of frac- h the epiphyseal cartilage and follows it.

Exclusively Through the Articular Surface of the Lower End

Fractures.—Supracondyloid fractures are more frequent and youth than in later years. The line of fracture passes,

1 Stimson's classification.) L. A. Stimson, *loc. cit.*, p. 242, 1907.

less common form the line of fracture runs from the anterior surface of the humerus above the elbow-joint downward and backward. It was characterized by Kocher as a "*flexion fracture*." Whereas, in the former group, the lower fragment is displaced *backward* and somewhat *upward*, in the flexion fractures the displacement is *forward* and *upward*, though it is not apt to be so marked a displacement as in the former variety. In both forms, angular displacement

FIG. 108. — SUPRACONDYLOID FRACTURE OF THE RIGHT HUMERUS. Flexion fracture. Line of fracture high. Internal view.

FIG. 109.—ANTERIOR VIEW OF FIG. 108. Flexion fracture of humerus.

FIG. 110.—EXTERNAL VIEW OF SUPRACONDYLOID FRACTURE SHOWN IN FIG. 108.

may be marked. Flexion fractures may occur from direct violence applied to the posterior surface of the ulna in the direction of the long axis of the humerus. It is highly important to distinguish these two forms of fracture, and owing to the different characters of the displacements this can usually be done.

In the extension fractures the lower fragment, together with the bones of the forearm, are displaced backward. In typical cases, inspection of the limb from the side exhibits a posterior angular deformity. The two bony fragments form an obtuse angle with the apex directed forward and the deformity is one which suggests a posterior dislocation of the humerus. The dislocation, however, can readily be excluded upon observing that the normal relations of the condyles to one another and to the olecranon process are preserved, as well as that the head of the radius is in normal relation to the external condyle.

FIG. 111.—SUPRACONDYLOID FRACTURE OF THE HUMERUS. Flexion fracture. X-ray. (New York Hospital collection.)

In examining the relations of the bony parts about the elbow and comparing the two limbs, a convenient method, which is applicable to many cases, without a general anesthetic and in all cases with such, is to have the patient's hands placed upon his forehead with the elbows flexed and projecting forward. They may be held in this position by an assistant, while the surgeon compares by inspection and palpation the relations of the bony parts about the elbows of the two sides. The thumb and middle finger of either hand may be placed upon the external and internal condyles, respectively, while the forefinger palpates the tip of the olecranon process. A T-shaped or Y-shaped fracture, or a fracture of either condyle, may be excluded by finding that the condyles cannot

be moved one upon the other and that compression of the condyles toward one another does not cause pain. The general symptoms and signs of fracture are all present. There is loss of active motion, passive motion is painful, pressure upward upon the olecranon process causes pain, and if the condyles are grasped in one hand, while the shaft of the humerus is held in the other, the condyles can be moved, independently of the shaft, from before backward or laterally, and at the same time crepitation can usually be elicited. The elbow is usually notably swollen and the swelling is equally diffused. Ecchymosis is a common sign present after some hours or a day. In the *extension* fractures it is usually possible to feel the sharp lower end of the upper fragment in the flexure of the elbow. Local tenderness can be detected by pressure with the finger along the outer or inner border of the humerus just above the elbow-joint, and in some cases, if the swelling be not too great, an irregularity in the outline of the bone may be detected in this situation.

A very important deformity which may cause subsequent disability is an angular rotation of the lower fragment toward the ulnar side. This "cubitus varus" is not infrequent as the result of these fractures. It is probably caused by improper dressings during the treatment. Its importance has been especially dwelt upon by L. A. Stimson.[1]

An important displacement, apparently due in part to the dressing, to the support of the limb by a sling under the elbow, aided perhaps by muscular contraction, or primary displacement in a fracture by adduction, is the angular lateral deviation of the lower fragment with the apex directly outward. The deformity of the elbow which results is very noticeable in extension and has usually been attributed solely to the ascent of the internal condyle after its fracture, but there is good reason to believe, I think, that it is much more frequently the result of a supracondyloid fracture followed by this angular displacement.

In the cases in which the line of fracture runs obliquely from above and in front, downward and backward, the signs of fracture as described will all be present, but the deformity will be less marked. There is no posterior displacement. The vessels and nerve trunks may be injured in supracondyloid fractures, and yet these accidents do not occur as frequently as might be expected from the character of the injury.

Fractures of the Internal Condyle.—Whereas supracondyloid fractures are very common among children, fractures of the internal condyle are less so. They are, however, fairly common among adults. The line of fracture runs from the internal border of the bone downward and outward to end somewhere upon the trochlear surface or even at or beyond its internal border in the capitellum. The fracture may be produced by violent abduction or adduction of the arm, tearing away or pushing away the internal condyle, respectively; more commonly, however, the fracture is caused by direct violence, as from falls

[1] L. A. Stimson, *loc. cit.*, p. 242, 1900.

upon the elbow, the force being transmitted direct through the condyles or through the medium of the olecranon. The character of the displacement is varied. In the fractures produced by falls upon the elbow, or by violent adduction of the forearm, the displacement will be upward and inward, or upward, inward and backward. In the fractures caused by traction and abduction of the arm, the displacement may be downward. The degree of displacement varies in extent, largely depending upon whether the radius is at the same time dislocated. If not, the ulna remaining attached on the one hand to the condyle, on the other, to the radius, the fragment cannot be very greatly displaced. If

FIG. 112.—SUPRACONDYLOID FRACTURE OF THE LOWER END OF THE HUMERUS. (New York Hospital collection. X-ray.)

FIG. 113.—FRACTURE OF THE INTERNAL CONDYLE OF THE HUMERUS. (New York Hospital collection. X-ray.)

the radius is dislocated, the fragment of the humerus may be markedly displaced backward, together with the ulna, so that at the first glance the appearance may closely resemble a posterior dislocation of both bones of the forearm. In some cases a rotary displacement of the fragment has been observed. The fragment may also be sharply tilted forward. In the last two forms of displacement the reduction is often very difficult and may require an incision

and direct replacement. In this fracture also the occurrence of cubitus varus as a late result is by no means uncommon. In these cases it is produced by the support of the elbow, exercising upward pressure upon the fragment through the medium of the ulna, or, as suggested by Stimson, in some cases, where the fracture occurs in young persons before the full development of the bone, it may be due to interference with the growth of the internal condyle as the result of the injury.

The *diagnosis* of fractures of the internal condyle is usually not difficult. There is loss of function, pain, uniform swelling about the elbow-joint. The relation between the olecranon and the internal epicondyle is preserved. Usually in uncomplicated cases the swelling is so marked that the changed relations between the internal and external epicondyles are not easy to appreciate. The existence of a fracture is usually easy to recognize upon palpation. If the fragment of the condyle is grasped between the finger and thumb, it may be moved backward and forward against the shaft of the bone, usually with the production of crepitus. If the forearm be partly extended, excessive motions of adduction and abduction at the elbow-joint may be made. Pressing the two condyles together causes pain. Pressure upon the olecranon as well, and pressure against the lower end of the humerus by the bones of the forearm when the elbow is partly flexed, is painful also. If dislocation of the radius coexists, the head of the bone may be felt below and behind the external condyle, and in these cases the forward projection of the external condyle and lower end of the shaft may be quite marked. It may be possible to detect the irregularity in outline of the lower end of the humerus and the absence of the internal condyle from its normal position. As already stated, a general anesthetic is often desirable in examining these more severe injuries of the bones of the elbow.

Fractures of the External Condyle of the Humerus.—This is relatively a frequent form of fracture, notably in young persons. Causes are, falls upon the elbow or hand while the former is flexed, the violence being transmitted through the ulna or radius respectively; violent adduction of the forearm tearing away the condyle by traction through the external lateral ligament. The line of fracture runs obliquely from without downward and inward, and the fragment includes the condyle with its epicondyle and the capitellum, sometimes the outer part of the trochlea. The degree of displacement is usually slight, since the fragment remains attached to the radius by the ligaments. Pressing the condyles together causes pain. In some cases there is a marked tendency toward tilting and rotation of the fragment in one of several directions, such that replacement may be difficult. In some cases there is a tendency for the fragment to slide upward, and in these, after healing has occurred, there may be a marked increase in the normal valgus position of the forearm. The fracture is sometimes associated with posterior dislocation of the ulna. Usually the diagnosis is not difficult if the patient is seen soon after the accident, yet here, as in all serious injuries about the elbow-joint, the lesions of the bones may soon become obscured by swelling, which, although it first appears on the

side of the limb corresponding to the site of fracture, soon becomes general and is often excessive. The same is true of the appearance of ecchymosis. If the limb be examined soon after the accident the appearance of ecchymosis upon the outer or inner aspect of the joint may give a hint as to the nature of the injury, but if seen only after the lapse of many hours or a day or two, the situation of the ecchymosis is not distinctive, since by that time it will have become diffuse, or have made its way by gravity to the dependent surface of the limb. Upon examining the bony points of the elbow, the external epicondyle will be found displaced from its normal relations, and though in the ordinary relaxed position of the limb such displacement is usually slight, it can be increased by lateral motions, as already indicated.

If the fragment is tilted or rotated the X-rays may be a valuable aid to the surgeon in determining the nature of the displacement and the efficiency of his efforts at reduction. During the manipulations of the fragment and of the forearm, crepitation is usually elicited, as well as abnormal mobility. When associated with posterior dislocation of the ulna the projection of the olecranon process backward and its posterior relation to the internal condyle will make the diagnosis simple.

Fractures of the External Epicondyle.—Isolated fracture of the external epicondyle is a rare and not very important injury. The diagnosis of such a fracture is seldom made. The injury, when it occurs alone, has nearly always been produced by direct violence. There is, therefore, notable contusion and swelling of the outer aspect of the elbow. The occurrence of an extra-articular fracture of this portion of the bone is denied by many surgeons, and Stimson states [1] that "an anatomical demonstration of the fracture has never been made except in connection with more extensive fractures of the elbow." The diagnosis of the breaking off of a portion of bone in this situation, however minute, can readily be demonstrated by X-ray pictures. In dislocations of the bones of the forearm backward fractures of the external or internal epicondyle are not rare.

Fracture of the Internal Epicondyle.—This fracture is very commonly associated with dislocation of the elbow, but may occur alone. The process of bone which is included in this fracture is a small one projecting from the inner border of the internal condyle. It is a fairly common injury in children. The diagnosis of the exact character of the injury can best be made by means of X-ray pictures, though usually most of the signs of fracture can be made out. There are swelling, ecchymosis, localized pain and tenderness, and sometimes crepitation can be elicited by moving the small fragment against the internal condyle. Fractures in this situation may be accompanied by contusion or laceration of the ulnar nerve with pain in the ulnar distribution, which may subside or be followed by a neuritis. (See Injuries of the Nerves of the Upper Extremity.)

[1] L. A. Stimson, *loc. cit.*, p. 246, 1900.

Intercondyloid, the so-called Y- and T-shaped Fractures.—As already stat these complicated fractures of the lower end of the humerus are commonly t results of very severe degrees of violence. The lower end of the shaft may broken in such manner that a line of fracture crosses the bone transversely

FIG. 114.—T-SHAPED FRACTURE OF THE LOWER END OF THE HUMERUS.
(New York Hospital collection.)

obliquely and is joined by another line of fracture passing vertically upwa separating the condyles one from the other (T-shaped fracture). In some stances both condyles are separated from the shaft, leaving a more or less sh projecting end at the extremity of the upper fragment (Y-shaped fractur In addition, there may be comminution of the lower end of the shaft. Ow to the extreme degrees of violence necessary to produce these fractures, they frequently compound, or may become so from sloughing of the contused ov lying tissues, and are not infrequently associated with injuries of the vessels a nerve trunks.

The signs and symptoms are very marked. The diagnosis of a complicated fracture is readily made. On the other hand, the exact character of the injury may be very difficult to recognize by ordinary means of examination. The soft parts are often greatly swollen. Abnormal mobility of the condyles, with reference to one another and to the shaft, may be made out on palpation, if the swelling is not too great. Here, as elsewhere, an accurate diagnosis is best made by means of stereoscopic X-ray pictures. These fractures are frequently followed by marked diminution of function in the elbow-joint after union has occurred. This will depend upon the changed relations of the bony surfaces and upon callus production, so that the movements of flexion and extension of the elbow are interfered with mechanically. Improvement sometimes follows an open operation and the removing of the projecting masses of new bone, or by cutting through the displaced condyles and putting them in better position. In young persons, however, if a moderate degree of flexion and extension, together with rotation of the radius, are preserved, mere external deformity is, in my opinion, hardly an indication for operative interference. The injuries of the blood-vessels and of the nerves will produce their own symptoms, sufficiently indicated elsewhere.

Separation of the Lower Epiphysis of the Humerus.—Separation of the lower epiphysis of the humerus occurs in children up to the age of fifteen years as the result of falls and blows upon the elbow, or in falls when the violence is

FIG. 115.—SEPARATION OF THE LOWER EPIPHYSIS OF THE HUMERUS SIMULATING POSTERIOR DISLOCATION OF THE ELBOW. (New York Hospital collection, service of Dr. P. R. Bolton.)

transmitted through the bones of the forearm and hand. The most importa points in the diagnosis of the injury are the age of the patient, the history the accident, the pain and loss of function in the limb, the discovery that th condyles retain their normal relations to the olecranon process and the head o the radius, of abnormal mobility of the lower fragment, accompanied usually by a soft crepitation. The displacement is usually backward and inward, more rarely outward, is readily reduced, and tends to recur at once—i.e., in a backward direction. In addition to antero-posterior mobility, abduction and adduction of the forearm, while the humerus is held fixed, can be carried out to an abnormal degree and is accompanied by pain. In making a diagnosis of these fractures by means of the X-rays, the surgeon should be familiar with the history of the ossification of the lower end of the humerus, and should, if possible, compare the X-ray plates of the injured limb with those of the sound side, or of the bones of another subject pictured at the same age. This is important, because, as has already been pointed out under The X-rays in Surgical Diagnosis and elsewhere in this book, cartilage casts so faint a shadow that it cannot be recognized in a picture showing bony structure. With due regard to these cautions and care in interpreting the X-ray plates, the diagnosis of separation of the lower epiphysis of the humerus can usually be made in children without serious difficulty. It is to be borne in mind that in some of the cases the fracture passes through a line which leaves the internal epicondyle or the external epicondyle, or both, attached to the shaft.

Fractures Exclusively Through the Articular Surface of the Lower End of the Humerus.—These fractures may involve the trochlea or the capitellum, or both. The fractures of the articular processes of the humerus occur as the result of violence transmitted through the radius and ulna. Fractures of the capitellum alone are more common than fractures of the trochlea. Of the former I have seen several cases as demonstrated by means of the X-rays, and in all of them the fracture was associated with fracture of the head or neck of the radius. In one of the cases about one third of the inner part of the head of the radius was broken and separated from the rest of the bone. It was demonstrated by means of an X-ray picture detached completely and lying within the elbow-joint. I operated and removed it, discovering at the same time that a small scale of bone, including the overlying cartilage, had been broken off from the capitellum. The functional result in this case was excellent. In the few reported cases of fracture of the trochlea the symptoms have been moderate pain and disability, and in some of them the loose fragment could be felt lying posteriorly between the head of the radius and the ulna. The simplest means of diagnosis is by the use of the X-rays.

Diagnosis.—In regard to the diagnosis of fractures of the bones in the vicinity of the elbow-joint, it cannot be too strongly urged that the examination should be conducted in every instance with great thoroughness. The relations of the bony landmarks about the joint should be studied with great care and compared with the relations upon the sound side. Inasmuch as fractures near

the elbow are regularly attended soon after the injury by marked swelling, the recognition of these bony relations is not always easy. Palpation and manipulation of the limb is often extremely painful, and notably when the patients are children the examination may be difficult without the administration of a general anesthetic. When the examination is found difficult or unsatisfactory, such should always be administered. The surgeon will then be able to make a much more accurate diagnosis and at the same time to reduce the displacements which exist and apply appropriate dressings. If, when first seen, the diagnosis is not clear, X-ray pictures may be taken at once, if an apparatus for the purpose is conveniently at hand, and upon the day following, when the surgeon proposes to apply permanent dressings, he will be, from the information obtained from successful plates, in a far better position to appreciate the nature of the lesions and to apply appropriate treatment. In the presence of great swelling it is sometimes useful to put the patient in bed for twenty-four hours and to suspend the limb vertically in some suitable wet antiseptic dressing, which may be combined with firm pressure, either by an ordinary or by an elastic bandage. By this means much of the swelling and edema will be caused to disappear, and the examination and reduction of displacements will be far easier. That these pains and precautions are not unnecessary is within the experience of every surgeon who has had a large out-patient department service, since he will have seen numerous unfortunate results of fractures in this region, most of which might have been avoided had the original examination been carefully and intelligently made and followed by intelligent treatment.

FRACTURES OF THE BONES OF THE FOREARM

Fractures of the Upper Ends of the Ulna and Radius

Fracture of the Olecranon Process.—From its prominence and its exposed position, the ulna is frequently the site of fractures by direct violence. In many of the instances the fracture is produced by a combination of forces—namely, by the external violence exerted upon the bone itself, tending to break it across the articular surface of the humerus, and also through the powerful traction exerted by the triceps muscle. Fractures of the olecranon also occur as the result of muscular violence, as in a powerful effort of extension of the elbow, such as is made in throwing a baseball, or the like. In the latter group the fragment is small, frequently a mere scale of bone. The olecranon process may also be fractured by hyperextension of the elbow, though fracture of the shaft of the ulna is more apt to be produced under these circumstances. Owing to the mode of production in the majority of instances—namely, by direct violence—the amount of contusion and swelling of the soft parts overlying the bone is often great. In some instances the fracture is compound.

The signs and symptoms of fractures of the olecranon in ordinary cases are easily recognized. There is usually complete loss of power to extend the fore-

arm. There is swelling and ecchymosis of the elbow, there is pain on pressure over the seat of fracture. By grasping the olecranon between the fingers and thumb it can usually be moved laterally, independent of the shaft of the ulna. The line of fracture is usually oblique, though it may be transverse across the narrowest portion of the process. In the latter group the amount of separation may be considerable, so that the examining finger sinks into a distinct gap, and this gap may be increased by passive flexion of the elbow-joint. In the oblique fractures the separation is less marked and in many instances can hardly be appreciated upon palpation. There will always be, however, along the line of fracture marked tenderness. By extending the forearm, it is sometimes possible to crowd the bony fragments together and, by moving the olecranon laterally, to elicit crepitus. In cases of doubt, where the positive signs of fracture cannot be obtained, an X-ray picture or pictures of the elbow will reveal its presence if it exists.

FIG. 116.—FRACTURE OF THE OLECRANON PROCESS OF THE ULNA. (Author's collection.)

Bony union following the nonoperative treatment of fracture of the olecranon has been observed in a few cases only. In most instances union takes place by fibrous tissue merely. Usually two lateral bands are formed, one on each side, with a space between. The completeness of restoration of function in the given case depends largely upon how close this fibrous union is and upon how firm the bands. It will also depend upon whether the smaller fragment retains its true alignment in the antero-posterior and frontal planes to the shaft, or whether it is, on the other hand, tilted so as to interfere mechanically with the motions of the joint in flexion and extension. In the cases in which the union is close and firm, little or no disability may remain. If, on the other hand, the separation of the fragment is considerable, one or two centimeters, the power of

extending the forearm will be distinctly diminished. It is to be borne in mind that these fractures enter the elbow-joint and that immediately after the injury

FIG. 117.—OBLIQUE FRACTURE OF THE OLECRANON WITH VERY MARKED SEPARATION.
(Author's collection.)

the joint becomes filled with blood, so that the resulting inflammation may cause adhesions between the joint surfaces. In a few cases this has resulted in ankylosis. In a few cases, also, failure of union has been observed, and in these the

FIG. 118.—FRACTURE OF THE OLECRANON WITH SEPARATION OF THE FRAGMENTS.
(New York Hospital collection.)

power of extending the elbow by contraction of the triceps muscle has been greatly diminished, although the individual may accustom himself to the disability in such a manner that it is scarcely noticeable. In the average case conservative treatment with splints and sticking-plaster, the elbow being placed in such a position that the fragments are easily kept in contact, is all that is necessary. In cases in which wide separation occurs, which is not easily overcome, and in cases of failure of union, an open operation, with suture of the fragments, has been attended by good results in a number of instances. In two such cases I obtained a good result by drilling the fragments and suture with heavy chromic catgut. In another a similarly good result was obtained by suture of the aponeurotic structures merely. The latter is probably a better operation than drilling of the fragments. Wires are to be avoided. When sutured, bony union of the fragments may be expected in most cases, in a few close fibrous union merely.

Fractures of the Coroncid Process of the Ulna.—Fracture of the coronoid process of the ulna is a frequent complication of posterior dislocation of both bones of the forearm. In these cases the process is broken off by impact against the articular surface of the humerus, as the bones are forced backward. As an isolated lesion, fracture of the coronoid process is rare. Stimson [1] mentions a case in which this fracture occurred in a case of his own by forcible flexion of the elbow during an operation for resection of the joint.

The process is held so closely in its position by the tendon of the brachialis anticus muscle, which is attached in front of it at its base, and by the capsular ligament of the elbow-joint, which is attached along its borders, that in most cases there is very little displacement. I have seen one case of fracture of the coronoid process associated with fracture of the neck of the radius without dislocation. (See Fracture of the Neck of the Radius.)

The diagnosis of fracture of the coronoid process, assuming that no dislocation exists, is to be made from the history of an injury, especially of such an injury as might produce a backward dislocation, and by the presence of tenderness and swelling at the flexure of the elbow and the discovery by palpation of a movable fragment occupying the situation of the coronoid process. In some of the cases it has been possible to feel the small fragment and to make it grate against the ulna. The positive diagnosis in cases of doubt can best be made by means of an X-ray picture. In cases of posterior dislocation of both bones of the forearm, the existence of the fracture might be suspected if the dislocation were readily reduced, but tended to recur.

Fractures of the Head of the Radius.—Since the X-ray examination of injuries of the elbow has come to be almost a regular practice, fracture of the head of the radius is recognized as a rather frequent injury. The line of fracture is usually vertical and most commonly involves the breaking off of a third or a fourth of the articular surface upon its inner side, though several fragments

[1] L. A. Stimson, *loc. cit.*, fifth edition, p. 272.

ıy be produced by severe degrees of direct or indirect violence, and in some these the head will be extensively crushed or comminuted. The fracture y be produced by direct violence, as from a blow upon the upper end of the ius, or by indirect violence transmitted through the radius by falls upon hand, or by falls associated with violent abduction of the forearm. imson.)

A case of fracture of the head of the radius which is now under my care e Fig. 119) seems to have been produced by indirect violence. The frac-

Fig. 119.—Fracture of the Head of the Radius. (Author's collection.)

ture differs from those ordinarily observed in that the line of fracture is not vertical but oblique, nearly transverse, and yet crosses distinctly through the head and not through the neck of the bone. Reference to the figure in the text will permit the reader to see that the fracture extends from the anterior sur-

face of the head of the bone at its junction with the neck, backward and slightly upward, so that the posterior border of the fragment does not include the posterior border of the head of the bone. There is very slight anterior displacement of the fragment, which is not separated from the remainder of the bone. At the present time, about six weeks after the injury, there is some limitation of flexion in the elbow-joint. The elbow can be flexed only a few degrees beyond a right angle. The method of production in this case was as follows: The patient is a man who, as he turned sidewise while walking upon an uneven floor, caught his toe in a projecting inequality and fell sidewise. His arm and hand were extended vertically by his side, practically in the military position—that is to say, with the middle finger of his hand along the seam of his trousers. As he fell he kept his arm in this position and struck the floor with his arm extended and under him. He feels quite sure that there was no side strain brought upon the elbow-joint and that his elbow struck the floor at the point where it was injured. He suffered extreme pain in the elbow and found himself unable to make motions of supination and pronation, while active motions of flexion were exceedingly painful. The elbow became swollen, and ecchymosis appeared upon the inner aspect of the limb, just above the elbow-joint. I first saw him one week after the accident. There were no positive signs of fracture present, except tenderness over the head of the radius. Active pronation and supination were impossible. Flexion and extension were very painful and restricted. The X-ray pictures which I had taken showed the fracture as described.

In another case, which was under my care in the New York Hospital, the head of the radius was broken by a fall upon the hand. In this case the line of fracture was, as is the rule, vertical. The fragment, a small one, was found at the time of its removal, and, as previously shown by the X-rays, entirely detached from the head and loose in the elbow-joint. The fragment involved the inner third of the head of the bone. It was removed through an incision, and the functional result was excellent.

In general, the probable diagnosis of fracture of the head of the radius can be made by the history of an injury, localized pain and tenderness at the point of fracture, loss of the power of supination and pronation, pain upon making these movements passively, and restriction of active movements of flexion and extension. In some cases the diagnosis may be made by placing the thumb upon the head of the bone, while rotary motions of the shaft are made with the other hand. In this way the sharp edge of the anterior part of the large fragment can sometimes be felt when the hand is placed in a position of extreme supination. In some cases the smaller fragment can be palpated between the head of the radius and the olecranon. A good X-ray picture will always confirm the diagnosis.

Fractures of the Neck of the Radius.—Fracture of the neck of the radius has of late years come to be recognized more frequently, by means of the X-rays. The fracture may be produced by blows upon the forearm directly against

the upper part of the bone, or, as in one of my cases (see Fig. 120), by a fall upon the hand. In the case shown the fracture was impacted and was associated with a fracture of the coronoid process, as demonstrated by an X-ray picture. The latter fracture does not appear clearly in the figure, but was plainly shown in another plate taken from side to side, but which unfortunately was broken and therefore cannot be reproduced. The signs and symptoms of fracture of the neck of the radius are not always easy to recognize by means other than the X-rays. The line of fracture may be transverse or oblique, and in the latter group there is sometimes an angular displacement, the apex of the angle pointing outward. On palpation an irregularity in the contour of the bone may sometimes be appreciated. Active pronation and supination are usually impossible, and when made passively are very painful. Flexion and extension are restricted, there is extreme localized pain on pressure at the point of fracture. In the case shown the fragments were, as stated, impacted. In case the upper fragment is completely detached, it is sometimes possible to appreciate the fact by pressing upon the head of the bone with the thumb, while rotary motions are made of the shaft. The head may not take part in such motions, and crepitus may be elicited. The fracture is occasionally associated with fracture of the external condyle of the humerus. In cases in which very marked displacement or comminution of the head has been present, good results have been obtained by removing the head or its fragments through an incision.

FIG. 120.—FRACTURE OF THE NECK OF THE RADIUS. (Author's collection.)

Fractures of the Shafts of the Radius and Ulna

Fractures of the Shafts of Both Radius and Ulna.—Fractures of the shafts of both radius and ulna are very frequent and in some instances very serious injuries. The unskillful treatment of these fractures may result in very marked permanent disability, in gangrene of the limb, in ischemic paralysis (Volkmann), followed by an atrophied and useless limb, by great restriction or loss of the power of pronation and supination of the hand and wrist. The study, then, of these fractures and their accurate diagnosis is a very important topic, inasmuch as unfortunate accidents, as above mentioned, are more common after these than after most other fractures.

In adults, fractures of both bones of the forearm may be produced by direct or indirect violence, very rarely by muscular action and probably never by muscular action alone, assuming that the bones are healthy. By direct violence the bones are broken by blows upon the forearm, or as when the limb is bent across some unyielding obstacle, as one would break a stick across the knee. In other cases, where the bones are broken by great degrees of violence, the fractures may be compound and sometimes comminuted, the latter frequently resulting in loss of substance, sometimes in nonunion. The most frequent cause of fracture from indirect violence is from falls upon the hand.

In children these bones are broken rather frequently from falls upon the hand, and among them incomplete fractures are common. One bone may be completely broken, while the other is merely bent.

The lines of fracture vary in different cases. They may be transverse, or jagged, or oblique. The seat of the fractures, when produced by direct violence, will be at or near the point of application of the force. When produced by indirect violence, the fracture may occur at any part of the forearm, but the most common situation is at the junction of the middle with the lower third of the forearm, or just above or just below this point. In fractures by indirect violence the radius is often broken at a higher point than the ulna. The displacements are of three kinds. Angular displacement exists or may be produced by manipulation in all cases. In the transverse fractures lateral displacement, with or without overriding, is common. If the lines of fracture are oblique, the overriding may be very marked. Rotary displacement is often present in the radius, notably when the fracture occurs above the insertion of the pronator radii teres. The upper fragment is supinated by the action of the biceps, while the lower fragment does not follow it. If the radius is fractured and the ends of the fragments remain in contact, angular displacement forward of the radius may be produced. In some cases, where both bones are fractured at or near the same level, lateral displacement may occur, such that the fractured ends are displaced toward one another, and may lie very closely together. If such displacements are not overcome, union between the bones, as well as between the fragments, may take place, with loss of the power of pronation and supination and very marked disability. This form of displacement may be produced

by the unskillful efforts on the part of the surgeon to correct the deformity. Angular displacements, either anterior or posterior, are not likely to be followed by this serious complication, but if the bones are displaced laterally, efforts on the part of the surgeon to correct this displacement by squeezing the forearm from side to side may result in crowding all four fragments together, so that they assume a position more or less resembling that of the letter X. In making efforts at reduction, the surgeon should always have this possibility in mind and try to avoid it by crowding his fingers and thumbs between the fragments in order to force them apart during efforts at reduction.

A very common cause of diminished power of rotation of the radius and of supination of the hand may be an angular displacement of the fragments in

FIG. 121.—FRACTURE OF THE RADIUS AND ULNA NEAR THE WRIST-JOINT.
(New York Hospital collection.)

the direction of the ulna, which remains uncorrected. The radius and ulna are united along their adjacent borders by the interosseous membrane, a firm and nonelastic structure. The rotation of the radius takes place around an axis which passes through the head of the bone above, and through the lower end of the ulna below. The space between the shafts of the bones is greatest when the hand is in full supination. When pronated, the radius crosses the front of the ulna at an oblique angle and the mechanical arrangement is such that at no time is the interosseous membrane put upon the stretch. If angular displacement of the radius remains uncorrected, when rotation in supination takes place, the apex of the angle must move through an arc of greater radius than normal. Such movement is restricted by the tension of the interosseous membrane, and to this cause is due the limitation of pronation and supination, following an uncorrected angular displacement of the radius in a large proportion of cases. Stimson [1] considers this the most frequent cause of diminution of the power of supination and pronation following these fractures. If

[1] L. A. Stimson, *loc. cit.*, fifth edition, p. 278.

the bones are displaced toward one another, the production of a large amount of callus and new bone may result in mechanical limitation of motion on the part of the radius, or in some cases in bony union between radius and ulna, with total loss of rotation.

When the radius is fractured above the insertion of the pronator radii teres, the upper fragment is supinated by the action of the biceps, while the lower fragment, in case the fracture is dressed in the customary position, midway between pronation and supination, does not follow it. The loss of power resulting is usually not marked and may produce no permanent disability, yet in some cases, notably if the upper fragment is at the same time displaced toward the ulna, it may result in nonunion. I recall a case of this kind which I operated upon some years ago in the Roosevelt Hospital. The patient was a man who had received a fracture of both bones of the forearm. The ulna had been broken near its middle and had united. The radius had been broken some two and one half inches below its tuberosity for the attachment of the biceps. The line of fracture was quite oblique, and the upper fragment was displaced toward the ulnar side. The fragments of the radius remained ununited for six months. At this time I cut down upon the fracture. I found the fragments of the radius united by a band of fibrous tissue merely. The fragments were separated about an inch. The upper fragment was markedly supinated, and the line of fracture being oblique, the fractured surfaces were turned away from one another. The fractured ends of the radius were freshened, drilled, and sutured with catgut; the hand was put up in a fixed dressing, strongly supinated. Bony union was obtained, with an excellent functional result.

Signs and Symptoms of Fracture of Both Bones of the Forearm.—The diagnosis of fracture of the shafts of the radius and ulna is usually very easy. All the signs of fracture are commonly present—loss of power, deformity, abnormal mobility, pain and localized tenderness, and usually crepitation upon moving the fragments. These fractures are commonly attended during the forty-eight hours following the injury by very marked swelling of the limb, and it is this factor which renders the occurrence of the more serious complications probable in the event of unskillful treatment.

The diagnosis of the actual displacements of the bony fragments can sometimes be made out by careful palpation, best under general anesthesia. On the other hand, if, when first seen, the limb is greatly swollen, it will be desirable in every instance to have X-ray pictures taken, so that the exact nature of the displacements and the direction of the lines of fracture may be known. Further, after the efforts at reduction have been made, subsequent pictures should be taken, so that the surgeon may learn whether or not his efforts have been successful. The most difficult displacement to overcome, in my experience, is overriding, and in a few cases, in order to correct this, I have found it necessary to cut down upon the fractured ends and replace them under the control of the eye. If once accurately replaced, if the lines of fracture are not so oblique as to make the recurrence of displacement inevitable, it will, in ordinary cases

of transverse fracture, not be necessary to suture the bones, or to make any provision for their retention in position other than the maintenance of reduction by a skillful assistant or by the surgeon himself, while the dressings are being applied. In order to avoid the dangerous complications which may follow these fractures, the surgeon should watch the subsequent course of the case with great care. During the early days following the application of a dressing there are several dangers to be thought of and guarded against. They are: localized gangrene from the pressure of splints upon some particular part of the limb; ischemic contraction due to dressings too tightly applied; actual gangrene of the limb from strangulation of the vessels; and the occurrence of angular deformity at the point of fracture, due to imperfect immobilization, or to the improper use of a sling to support the forearm.

As a general caution applicable to every case, it may be said that no circular roller bandage should be applied directly to the skin; that the splints, whether of wood, tin, or plaster, should be applied in such a manner that they can by no possibility constrict the limb. In order to avoid such constriction, the splints should be suitably padded with some elastic material, and for this purpose anything is better, probably, than absorbent cotton; further, the splints should be rigid, so that, when a circular bandage is applied over them, it cannot bend the splints themselves and so mold them to the limb as to cause constriction. In the case of wooden splints, they should be thick enough to be quite rigid under the pressure of the bandage, and should be a little wider than the limb. Otherwise the adhesive plaster used to hold them in position may act as a constricting band. Localized areas of gangrene produced by the pressure of splints should be guarded against by careful padding over points of pressure and by immediate removal of the splints and inspection of the limb if the patient complains of a burning pain at any point. Ischemic contracture of muscles and gangrene of the limb are to be avoided by careful application of the dressings, by placing no circular roller bandage next the skin, and by extreme watchfulness on the part of the surgeon himself, as to the condition of the hand and fingers. It is a mistake to suppose that splints which are too tightly applied must of necessity cause great pain. Such is not the case. The fingers may simply become a little blue and cold and the patient may complain but little or not at all, and yet at the moment gangrene or loss of vitality of the muscles of the limb may be threatening.

The recurrence of angular deformity in the bones is to be avoided by the use of firm splints and by assuring oneself that as the swelling subsides the dressings are kept sufficiently snug to furnish due support. These patients are ordinarily permitted to walk about with the forearm in a sling, the hand being midway between pronation and supination. If the wrist merely is supported by such a sling, there will be a tendency for the weight of the forearm and arm to create an angular deformity with its apex downward or toward the ulnar side. If, on the other hand, the sling supports the forearm at or above the point of fracture merely, the weight of the limb distal to this point of support

will tend to create an angular deformity in the opposite direction. These occurrences can best be avoided by supporting the entire forearm from the elbow to the wrist evenly and equably.

In children, the diagnosis of fracture of both bones of the forearm is usually simple, but in these cases, if the fractures are incomplete, it may be that the deformity will not be noticed by the parents and the child may be brought to the surgeon with the story that after a fall upon the hand a mere sprain or contusion has been produced. A careful examination should be made for the signs of fracture, deformity, localized tenderness, and, if ten days or a fortnight has elapsed since the injury, the presence of a palpable enlargement of the bone at the point of fracture. In some cases one of the bones will be bent, while the other is fractured without displacement. The surgeon should in such cases examine carefully both bones throughout their entire length. Upward pressure against the palm in the long axis of the bones will cause pain at the point of fracture.

As stated elsewhere, failure of union is not very uncommon after fracture of both bones of the forearm. This can be best avoided by making the original examination and reduction under general anesthesia and in the most painstaking manner. If the examination and reduction can be made under the immediate control of the X-rays, so much the better. It is impossible to place any definite limit of time after which union cannot be expected. The same data are valuable here as in cases of fractures of the shaft of the humerus, elsewhere described.

FIG. 122.—FRACTURE OF THE RADIUS AND ULNA JUST ABOVE THE WRIST-JOINT. Hematoma upon the dorsum of the hand. (New York Hospital collection.)

In some cases one of the bones unites, while union in the other is delayed Final union need not be despaired of for many months. Under normal and favorable conditions union occurs in about four or five weeks, but it is rare that the individual is able to resume the active use of the limb in less than two or three months. During the early use of the limb, violent muscular efforts or continuous heavy strains in one direction should be avoided. Angular deformity from bending of the callus may thus be produced.

Fracture of the Shaft of the Ulna Alone.—Fractures of the shaft of the ulna ur from blows and falls upon the bone. They are nearly always fractures direct violence. In a considerable proportion of the cases the violence is

123.—Fracture of the Ulna Near the rist-joint. Antero-posterior view. (New ork Hospital collection.)

Fig. 124.—Fracture of the Ulna Near the Wrist-joint. Lateral view. (New York Hospital collection.)

ived as the individual holds his forearm upward and forward to protect his d and face. Such fractures are occasionally observed as the result of blows inst the ulna in prize fights. The degree and character of the displacement l vary much, according to the severity of the violence producing the fracture. many cases the displacement is slight. It may be entirely absent. Since radius acts as a support for the ulna, there is no overriding. The diagnosis to be made in most cases by ordinary methods of examination, and since rked displacement is so often absent, in these cases much reliance can be

placed upon the existence of a point of extreme tenderness along the shaft of the bone. In cases of doubt an X-ray picture will render the diagnosis certain. The commonest form of displacement is an angular one toward the radius. This should be sought for and overcome by local pressure with the thumbs crowded between the bones, thus forcing the ulna away from the radius. A not infrequent complication of fracture of the shaft of the ulna is dislocation of the head of the radius forward. This should always be thought of, and if the elbow is swollen, or the patient complains of pain in the vicinity of the elbow-joint, search should immediately be made for the signs of dislocation of the radius.

Fracture of the Shaft of the Radius Alone.—Fracture of the shaft of the radius alone is usually caused by direct violence, a blow or fall upon the outer aspect of the forearm, sometimes by indirect violence, as from falls upon the palm of the hand. A few cases of fracture by muscular action have been observed. As was mentioned when speaking of fracture of both bones of the forearm, one of the commonest forms of displacement in fractures of the radius is an angular one, the apex of the angle directed forward, though according to the nature of the fracturing force and to the direction of the line of fracture

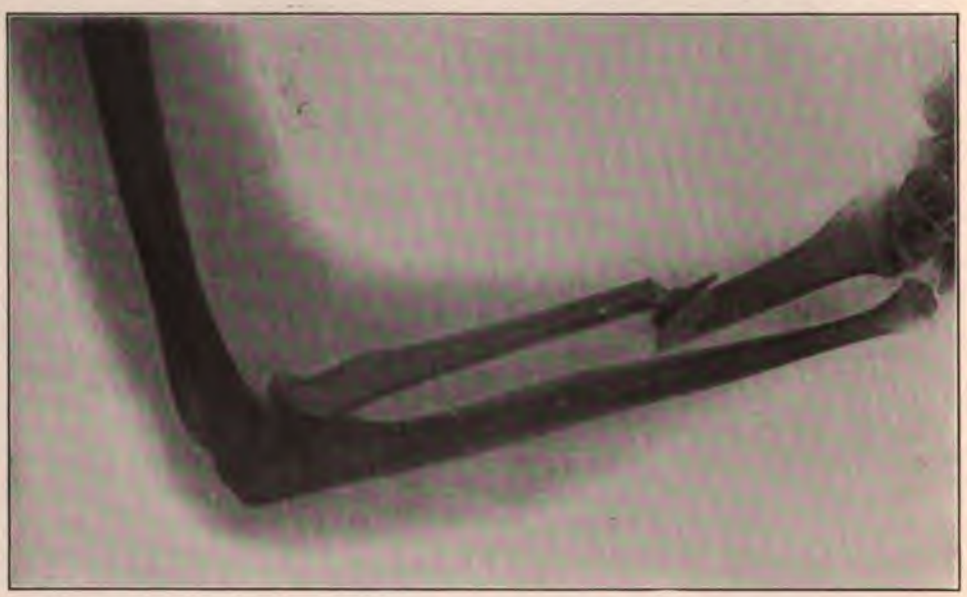

FIG. 125.—FRACTURE OF THE SHAFT OF THE RADIUS WITH SEPARATION OF A SMALL WEDGE-SHAPED FRAGMENT. (Case of Dr. Howard D. Collins, X-ray by the author.)

with reference to the axis of the bone, the displacements observed may be very varied in character. Here, as in fractures of both bones, if the fracture of the radius occurs above the insertion of the pronator radii teres, the upper fragment may be markedly supinated. If there is reason to suspect this form of displacement, an X-ray picture should be taken, or, better, stereoscopic pictures. If the suspicion is confirmed thereby, the dressings should be applied with the

hand fully supinated and kept in that position for about a fortnight. This position is an irksome one and usually causes the patient a good deal of discomfort. If the patient can be put to bed some of the discomfort may be obviated, since if the forearm be flexed at a right angle and the arm abducted the position of supination of the hand may be maintained with comparatively little annoyance.[1] In addition to the tendency toward an angular displacement forward, the muscles of the forearm tend to draw both the fragments toward the ulna and this displacement should be overcome if possible. Overriding does not occur from fractures of the shaft of the radius alone, unless it be associated with dislocation of the lower end of the ulna. The recognition of fracture of the shaft of the radius is usually not difficult. The ordinary signs of fracture are present, including loss of the power of rotation of the bone, localized pain, tenderness, usually deformity and crepitation. The loss of continuity between the head and the shaft may readily be made out, as already described, by placing the thumb upon the head of the bone and making gentle rotary movements at the wrist.

Fracture of the Lower End of the Radius—Colles's Fracture

Fracture of the lower end of the radius is one of the most frequent of all injuries to bone. It occurs at all periods of life, though more common in adults than in children, and is notably frequent in old women. As ordinarily described, Colles's fracture includes those fractures of the lower end of the radius which occur within one inch of the articular border of the bone, although Colles believed that the ordinary site was distant about an inch and a half from the lower end of the radius. The most common cause of the fracture is a fall upon the palm of the outstretched hand, usually not a fall from a great height, but simply a fall from the standing posture to the ground. In falls from a considerable height, upon the extended palm more serious and complicated injuries are often produced. Even in the simpler cases the lower fragment is frequently comminuted. The line of fracture is commonly transverse, often it is oblique laterally as well as from before backward. Among children, and up to the age when the epiphysis unites, usually during the nineteenth year of life, the line of fracture may follow that of the epiphyseal cartilage. The commonest form of displacement is that the lower fragment is rotated about its anterior border as a center and is displaced upward, backward, and outward, frequently with crushing of the cancellous tissue of the posterior aspect of the shaft. Accompanying the crushing, impaction is quite common, so that while many of the positive signs of fracture are present, abnormal mobility and crepitation are sometimes absent, or are only observed when the impaction is broken up under a general anesthetic in the effort to overcome the displacement. At the same time that the lower fragment is rotated dorsally, it is frequently displaced somewhat to-

[1] L. A. Stimson, *loc. cit.*, fifth edition, p. 280.

ward the radial side. In this displacement, the articular surface continues to bear its normal relations with the bones of the carpus, so that the wrist and hand accompany the lower fragment. The lower end of the ulna becomes very prominent, one of the characteristic signs of this fracture.

The regular study of injuries to the wrist with the X-rays has thrown light upon the pathology of fracture of the lower end of the radius. It has been found that associated with the displacement already mentioned there is often extensive comminution of the lower fragment, and it is important for the surgeon, as well as the patient, to have an X-ray examination made; since, in some of the cases, complete reposition of the fragments will, on account of such comminution and impaction, be found possible. Fortunately, the functional results obtained do not appear to be unsatisfactory, even when considerable deformity exists. A prominence of the lower end of the ulna and more or less marked displacement of the hand and wrist toward the radial side not infrequently remain as permanent deformities after Colles's fracture in adults.

A few cases of fracture of the lower end of the radius, such that the line of fracture ran from the radial border of the bone downward and inward separating the styloid process and a part of the articular extremity of the bone, have been described. They are rare injuries and the diagnosis can best be made accurately by means of an X-ray picture. See also Figs. 105 and 106, Vol. I, pages 278 and 279. The fragment may be displaced upward.

Certain other injuries may be associated with fracture of the lower end of the radius. They are, fracture of the styloid process of the ulna. This occurs with considerable frequency and has been demonstrated in half the cases examined, by certain observers. (Scudder.) Another and more serious complication is penetration of the skin by the lower end of the ulna, rendering the fracture compound. Another complication mentioned is rupture of the radio-ulnar ligament, or tearing away of the interarticular triangular fibro-cartilage at its insertion into the base of the styloid process of the ulna. This is a very difficult lesion to demonstrate, since, as elsewhere noted, cartilage casts no visible shadow when interposed between a source of X-rays and a photographic plate. Scudder considers this complication as probably quite frequent and believes that it accounts in part for the broadening of the wrist-joint observed in Colles's fracture. Very rarely the fracture of the radius itself may be compound, though such an injury can only occur from extreme degrees of violence, such as falls from a considerable height upon the hand, and is not produced by the ordinary degrees of violence, such as are followed by simple fracture of the lower end of the radius. Fracture of the carpal scaphoid is rarely observed as a complication of Colles's fracture. Fracture through the lower portion of the shaft of the ulna sometimes accompanies fracture of the radius. In some instances both bones are broken within an inch or two of the wrist-joint. In these the extreme mobility of the fragments, the deformity and other signs of fracture, are very readily recognized. Fracture of the styloid process of the ulna can sometimes be recognized on palpation by the mobility

of the small fragment. It is more certainly made out by means of an X-ray picture.

Examination and Diagnosis of Fractures of the Lower End of the Radius.—Since failure to reduce the deformity of Colles's fracture often casts, justly or unjustly, an undesirable reflection upon the skill of the surgeon, and since failure to recognize this fracture is justly considered culpable on the surgeon's part, the examination should be made with great care. It is quite true that in many cases of Colles's fracture the diagnosis can be made at a glance, yet such is not always the case. The deformity may be slight or absent and in many instances the lesion has been at first regarded as a mere sprain of the wrist. It is desirable here, as is the case with other fractures in the vicinity of joints, to compare the sound with the injured side, and it is well to familiarize oneself with the normal anatomy of the bony landmarks at the wrist in the particular case before seeking the departures from the normal in the injured limb.

FIG. 125.—FRACTURE OF THE LOWER END OF THE RADIUS IN A CHILD. Dorsal displacement of the lower fragment. This case illustrated well the value of stereoscopic X-ray pictures. In the single picture the displacement is not evident, in the stereoscope it could be seen clearly. (Author's collection.)

When the hand is held in supination, the styloid process of the radius is found to be at a lower level—that is to say, nearer the hand—than the styloid process of the ulna. It is to be borne in mind also that the articular surface of the ulna in males approaches more nearly to the level of the articular surface of the radius than is the case with females. In fractures of the lower end of the radius the styloid process is displaced upward along with the lower fragment, so that upon the injured side the radial styloid process will be found at or near the level of the styloid process of the ulna instead of being lower—i. e., nearer the hand. In making the examination it is always desirable to ask the patient whether he has received a previous injury to the wrist-joint, since separation of the lower epiphysis of the radius in children may be followed by an arrested or imperfect growth of the bone, so that the styloid process of the radius in these cases may be higher even than that of the ulna. In making the

comparison the two wrists may be held and the ends of the styloid processes palpated with the thumbs. It is also well to make the various physiological motions in the sound as well as in the injured wrist, flexion and extension, abduction and adduction, as well as supination and pronation. If the injury is evidently a severe one, the examination may well be conducted under a general anesthetic, since the reduction of the displacement will be easier and, of course, painless when so performed.

The deformity of Colles's fracture of the radius is usually quite characteristic. The lower fragment creates a prominence upon the dorsum of the limb, the ulna is prominent to the inner side, the whole hand and carpus are displaced toward the radial side. Upon the palmar surface the transverse creases of the skin are more marked, and just above the level of the wrist there is usually a noticeable prominence of the flexor tendons, which falls away abruptly below. The deformity was called by Velpeau many years ago the "silver-fork fracture," and the outlines of the hand and wrist correspond quite accurately to this simile. Upon palpation, there is always marked tenderness upon the back of the limb over the line of fracture in the radius. In the absence of all other signs of fracture this is a very important sign, and if crowding the carpus upward in the line of the limb causes pain in the same place a positive diagnosis of fracture may usually be made. In many instances the prominence of the displaced fragment is readily made out at the same time

FIG. 127.—FRACTURE OF THE LOWER END OF THE RADIUS, SHOWING RESULT OF OPERATION FOR RELIEF OF DEFORMITY. (Author's collection.)

that the surgeon is examining for a line of tenderness. As already stated, the symptoms of crepitus and abnormal mobility are often absent on account of the frequency with which these fractures are impacted. In cases of doubt an X-ray examination should always be made, for in the past it has happened many more times that the presence of fracture was not recognized than that a fracture was diagnosticated when none existed.

Certain other lesions may possibly be mistaken for fracture of the lower

end of the radius. Separation of the lower epiphysis will be observed only in children, or in young persons under nineteen years of age. It can be differentiated from typical fracture of the lower end of the radius by the fact that the dorsal displacement is not very marked, nor is the displacement toward the radial side as marked as it is in true fracture. The displacement also is, as a rule, much more readily reduced than is the case with an ordinary fracture, and crepitation may be elicited of a softer character than is produced by bone. In cases of doubt the X-ray furnishes an accurate means of diagnosis. Union occurs promptly after separation of the epiphysis and is only occasionally followed by interference with the growth of the bone.

Sprains and contusions of the wrist may sometimes be mistaken for Colles's fracture. Absence of positive signs of fracture and an X-ray picture will render the diagnosis certain.

Dorsal or backward dislocation of the wrist is rarely mistaken for Colles's fracture. The dislocation is a far rarer injury. The normal relations of the

FIG. 128.—SEPARATION OF THE LOWER EPIPHYSIS OF THE RADIUS.
(New York Hospital collection.)

styloid processes are preserved, the deformity occurs at a lower point than is the case with Colles's fracture. Usually on palpation the bones of the carpus can be recognized upon the dorsum of the wrist, and reduction by traction upon the hand and pressure forward upon the bones of the carpus is usually easy, nor does it tend to reappear.

Prognosis.—The prognosis of Colles's fracture as to functional result is usually good. Firm union may be expected to occur in about four weeks. In adults, as already noted, it may be impossible entirely to correct the deformity on account of crushing, or comminution of the bone, and in these some dorsal and radial displacement, with prominence of the lower end of the ulna, may persist. The functional result, however, in these cases is usually quite good. In elderly people the stiffness of the wrist-joint and interference with free movements of the fingers may endure for many months and in certain cases is in part permanent. The greater the amount of inflammation around the fracture and in the tendon sheaths, the more the likelihood that such stiffness will be but slowly recovered from. The patient should be encouraged to move the joints of the fingers freely during the treatment. Massage, commenced early,

is an important aid. In young persons the resulting deformity is usually very slight, or absent, and the functional disability lasts a much shorter time than in the elderly. The operative treatment of old cases of fracture of the radius for the correction of displacement, although good results are reported by good surgeons, notably by Scudder and Lothrop, is not extremely popular among surgeons in general. The position of the lower fragment may be corrected by operation and the deformity may thus be removed in whole or in great part, but in the cases upon which I have operated myself and seen operated upon by others the functional results were not notably improved.

Rare Fractures of the Lower End of the Radius.—As the result of falls upon the back of the hand—i. e., upon the extended limb, the hand being in the posi-

FIG. 129.—SEPARATION OF THE LOWER EPIPHYSIS OF THE RADIUS.
(New York Hospital, Out-Patient Department, case of Dr. Eugene Pool.)

tion of palmar flexion—there are a few cases recorded in which the lower end of the radius has been broken, but where the displacement has been forward and outward instead of backward and outward as occurs in Colles's fracture. The lower fragment in these cases has rotated upon an axis corresponding to its posterior instead of its anterior edge with crushing of the palmar portion of the cancellous tissue of the bone instead of the dorsal portion as seen in ordinary fractures of the lower end of the radius. The deformity, as shown by inspection and palpation, has not been difficult to recognize. The lower end of the upper fragment has formed a prominence upon the dorsum of the forearm an inch or less above the line of the radiocarpal joint. A depression has been observed upon the palmar surface. There has been a line of tenderness at the point of fracture on the back of the wrist. Mobility and crepitation may or may not be present, according to whether the fragments are free or impacted.

As a rare complication of dorsal or of palmar dislocation of the wrist, a scale of bone may be torn off the dorsal or palmar surfaces of the radius,

respectively. The smaller fragment may be recognizable on palpation. It could readily be demonstrated by means of an X-ray picture.

DISLOCATIONS OF THE ELBOW

Of all the large joints the elbow is next to the shoulder most frequently dislocated. Errors in diagnosis and improper methods of treatment are frequent and lead to unfortunate results. Every surgeon sees many cases of old, unreduced dislocations of one or other of the bones of the forearm and not very rarely stiff elbows or elbows in which the function of flexion and extension is partly lost. The reasons for such unfortunate results are failure to recognize the nature of the injury and the use of methods of reduction which increase and unnecessarily extend the already considerable traumatism to the bones and soft parts surrounding the elbow-joint. It is therefore incumbent upon the surgeon to study very carefully the bony anatomical landmarks of the elbow in any case where dislocation may exist. If the case is not seen for many hours after the injury, the recognition of these landmarks may be so far obscured by swelling as to be very difficult, or even impossible. Under such circumstances it is the duty of the surgeon to have X-ray pictures taken of the elbow at the earliest possible moment, and if stereoscopic pictures can be taken, so much the better. We have in the X-rays a diagnostic aid which in these cases is simply invaluable.

FIG. 130. — POSTERIOR DISLOCATION OF RADIUS AND ULNA. (New York Hospital collection.)

Dislocations of the elbow occur with great frequency in children. They are more common during youth and early adult life than later and are about four times as frequent among males as among females. The dislocation may involve either the radius or the ulna, or both bones; and may take place in a number of directions. Both bones may be dislocated in the same direction, or in different directions, and the dislocations may be complicated by fracture of any one of the three bones involved in the injury. The classification, therefore, of dislocations of the elbow is of necessity rather complicated.

- **Dislocations of the Forearm on the Arm.**
  1. Dislocation backward.
     - Backward and outward.
     - Backward and inward.
  2. Lateral dislocations.
     - Incomplete: Inward. / Outward.
     - Complete outward.
  3. Forward dislocations.
     - Incomplete, or first degree.
     - Complete, or second degree.
     - With fracture of the olecranon.
  4. Divergent dislocations.
     - Antero-posterior.
     - Transverse.
- **Dislocations of the Ulna Alone.**
  1, 2. Backward and upward: 1. Incomplete, or first degree. 2. Complete, or second degree.
  3. Backward and outward, behind radius.
  4. Forward.
- **Dislocations of the Radius Alone.**
  1. Backward.
  2. Outward.
  3. Forward.
  4. By elongation, or the subluxation of children.
  5. Associated with fracture of the ulna.

Congenital and Pathological Dislocations

This is the classification of dislocations of the elbow adapted by L. A. Stimson:[1]

1. **Dislocation of Both Bones of the Forearm Backward.**—This is much the most frequent form of complete dislocation of the elbow. The dislocation is nearly always due to a fall upon the hand with the elbow extended, or nearly so. The mechanism of its production is thus described by Stimson:[2] "Forcible abduction of the forearm, during either extension or partial flexion of the elbow, is the first step in the production of the injury in a large number of cases; this breaks the internal lateral ligament and frees the ulna, and then the bones slip past each other, the external lateral ligament being torn or detached in the movement, and the head of the radius tearing off the corresponding portion of the capsule and adjoining periosteum as it slips up behind the condyle." In many cases the motion of hyperextension of the elbow puts the lateral ligaments upon the stretch and the additional force of abduction causes the ligament to give way.

The lesions produced by the dislocation are, as already stated, rupture of the internal lateral ligament and more or less complete rupture of the external lateral ligament, which is frequently completely stripped away from the humerus. Additional lesions described by Stimson in a case which he himself observed were as follows: The tip of the internal epicondyle may be torn away through its attached flexor muscles. The flexor muscles of the hand may also

[1] L. A. Stimson, *loc. cit.*, p. 614, third edition, 1900. [2] *Ibid.*

be torn from the humerus and the brachialis anticus may be lacerated or completely ruptured. The tendon of the biceps may slip upon the outer side of the external condyle. Stimson states that in the only case in which he saw all these extensive lesions the end of the humerus was stripped of all its muscles and had passed through the fascia and lay under the skin in the fold of the elbow, but the patient had been subjected to three attempts by different surgeons to reduce under ether, and it is probable that the lacerations were in part due to those attempts.[1] The radius and ulna may be displaced upward and backward a variable distance, and one of them may be displaced more than the other, so that the forearm may deviate farther to the ulnar or to the radial side.

FIG. 131.—POSTERIOR DISLOCATION OF THE ELBOW IN A CHILD. (Author's collection.)

Complications.—As already stated, fractures of any one of the three bones may complicate the dislocation. Fracture of the olecranon or of the coronoid process is the most common. Fracture of the head of the radius has already been mentioned as one of the complications which may follow such injuries as cause dislocation of the elbow. (See Fractures of the Head of the Radius.) Fractures of the other portions of the radius have been observed in a few cases. Injuries of the blood-vessels and nerves are rather rare, though recorded in a few instances. If the violence is extreme and continues to act after the dislocation occurs, the lower end of the humerus may protrude through the skin of the flexure of the elbow, thus rendering the dislocation compound. I had a case of this kind under my care in the New York Hospital some years ago; a woman who fell from a trolley car, striking upon her hand. In addition to dislocation of the elbow backward, there was a fracture of the olecranon. The lower end of the humerus

[1] L. A. Stimson, *loc. cit.*, p. 617, third edition.

had so far penetrated the skin that it sloughed through in the flexure of the elbow, rendering the dislocation compound. The wound remained aseptic, but, owing to the extensive laceration of the soft parts, some stiffness of the elbow remained at the end of six months, when I lost sight of the case.

a *b*

FIG. 132.—POSTERIOR DISLOCATION OF THE RADIUS AND ULNA.
a. Lateral view. *b*. Antero-posterior view. X-ray. (New York Hospital collection.)

Symptoms and Diagnosis.—If seen within a few hours after the accident, the position of the limb and the changed relations of the bony landmarks about the elbow-joint render a diagnosis by inspection and careful palpation sufficiently easy. If not seen until the end of twenty-four hours, the swelling of the soft parts about the elbow may be so great that the diagnosis may be difficult. Under these circumstances, as already stated, an X-ray examination is invaluable. In recent cases the elbow is usually held a little flexed, although it may

in rare cases be markedly flexed or extended. There is nothing characteristic about the supination or pronation of the hand; ordinarily the limb is held midway between pronation and supination, or is moderately supinated. The forearm is shortened. The antero-posterior diameter of the elbow is increased. If the swelling is not too great, the olecranon may be seen projecting posteriorly and forming a prominence from which the contour of the limb falls away

FIG. 133.—DISLOCATION OF THE RADIUS AND ULNA OUTWARD AND BACKWARD. Antero-posterior view. (Bellevue Hospital. Kindness of Dr. J. C. Ayer.)

FIG. 134.—DISLOCATION OF THE RADIUS AND ULNA OUTWARD AND BACKWARD. Lateral view. (Bellevue Hospital. Kindness of Dr. J. C. Ayer.)

upward, and upon palpation the triceps muscle may be felt passing down to be attached to the olecranon. Upon either side of its tendon there may be observed, if the swelling is not excessive, a depression. The head of the radius may be visible and is usually palpable to the outer side of the olecranon. In

front, the lower end of the humerus forms a prominence and the forearm appears to be broadened just below it.

Voluntary flexion and extension of the elbow are usually possible to a slight degree, but are painful. Pronation and supination, though painful, are usually preserved to some extent. Upon grasping the arm and forearm, lateral mobility

FIG. 135. — DISLOCATION OUTWARD AND BACKWARD OF THE RADIUS AND ULNA. Anterior view. (Drawings by Dr. B. S. Barringer.)

FIG. 136. — DISLOCATION OUTWARD AND BACKWARD OF THE RADIUS AND ULNA. Posterior view. (Drawings by Dr. B. S. Barringer.)

may be appreciated at the elbow. Palpation will reveal the olecranon forming the most prominent part of the elbow behind. If the epicondyles upon either side can be located, it will be noted that upon extending the limb the olecranon rises to a higher level than these bony points posteriorly. If the forearm be flexed, the prominence of the olecranon will be increased, and at the same time it will descend. The axis of the forearm may deviate to either side of the

median line of the limb; toward the ulnar side if the ulna is displaced farther upward, and toward the radial side if the radius has risen to a greater extent than the olecranon. If the olecranon is fractured, it may be recognized as a movable fragment. If the swelling be not very marked, the outlines of the lower end of the humerus, including its epicondyles and sometimes the border of the trochlea, may be recognized by palpation. A fracture of either condyle will under favorable conditions be detected by grasping the fragment and moving it independently of the shaft of the humerus. If, after reduction, the dislocation readily recurs, the coronoid process is probably fractured.

FIG. 137.—OUTWARD DISLOCATION OF THE RADIUS, FRACTURE OF THE OLECRANON WITH INCOMPLETE DISLOCATION OF THE ULNA OUTWARD AND FORWARD. Lateral view. (New York Hospital collection.)

It is important to recognize a fracture of the internal condyle with posterior dislocation of the radius. In this case the relation between the olecranon and the internal epicondyle will be preserved. The diagnosis, however, depends, as pointed out by Stimson, not upon attitudes, nor measurements, neither upon fixation nor abnormal mobility, but upon the recognition and identification of the epicondyles, the olecranon and the head of the radius in their new and abnormal positions. In case the swelling of the limb is such that these data cannot be made out with certainty, it will be necessary to have an X-ray examination. This is exceedingly important in dislocations of the elbow, because if unreduced they may soon become irreducible. This condition will usually be found if six weeks or more have elapsed since the injury, and will be caused by the formation of new bone from the stripped-up periosteum upon the posterior surface of the humerus, by the filling up of the cartilaginous joint surfaces, notably of the ulna, by fibrous tissue, by the formation of scar tis-

sue in the soft parts, and to some degree also by shortening of the lacerated muscles.

In regard to the reduction of dislocations of the elbow, it may be said that a general anesthetic is desirable, since by this means not only will the patient be spared unnecessary pain, but the reduction will be effected with the least possible amount of force and the smallest danger of producing additional injury to the bones and soft parts. Reduction can be effected with the greatest safety by traction in the long axis of the limb, in a position of extension, or even of slight hyperextension, while the surgeon presses upon the olecranon and head of the radius with his thumbs directly downward, grasping the front of the humerus with the fingers of either hand as a means of counter pressure. Under an anesthetic it is sometimes possible to reduce a dislocation of the elbow by direct pressure in this way, in the extended position, without the aid of an assistant, but in most cases it will be necessary and desirable that the assistant should make traction upon the forearm in the long axis of the limb.

FIG. 138.—OUTWARD DISLOCATION OF THE RADIUS, FRACTURE OF THE OLECRANON WITH INCOMPLETE DISLOCATION OF THE ULNA OUTWARD AND FORWARD. Antero-posterior view.

It has been pointed out by Dr. Stimson that in these, as well as in other dislocations, it is desirable in reduction to make the bones return to their normal positions in the same direction and by the same route as they left it. For this reason, I quote Dr. Stimson's recommendations, which bear upon this point:[1]

In all cases of doubt or difficulty anesthesia should be used; and, as a general rule, whenever a lateral displacement is associated with the backward one, the bones should be pressed sidewise into line before they are drawn downward.

When the lateral element of the displacement is very marked, and it is probable

[1] L. A. Stimson, *loc. cit.*, p. 623, third edition, 1900.

that the primary dislocation was directly outward and has been followed by a consecutive displacement backward, anesthesia should not be omitted, and after full relaxation has been obtained, the first attempt should be to move the olecranon and head of the radius to the radial side of the humerus and transform the dislocation into a pure outward one. By doing so the principle of replacing the bones by the route along which they have been displaced is followed, and the risk of engaging the tendon of the biceps behind the external condyle is avoided. If the attempt, cautiously made, does not succeed, the surgeon should next seek to change the displacement into a pure backward one and reduce as before described.

If some time has elapsed since the accident, more than ten to fifteen days, it may be desirable to break up such adhesions as have formed by flexion, extension, and lateral flexion, but it must be borne in mind that forced flexion always carries the risk of fracturing the olecranon.

The directly posterior and the posterior and lateral dislocations, concerning which no further description is necessary, constitute the vast majority of all dislocations of the elbow; purely lateral dislocations outward or inward are extremely rare.

2. **Lateral Dislocations of Both Bones of the Forearm.**—Incomplete Inward Dislocations.—The dislocation follows a fall upon the hand, occasionally blows upon the elbow or forearm. The mechanism consists of a rupture of the internal lateral ligament followed by a lateral displacement of the radius and ulna, so that in a case reported by Sprengel and quoted by Stimson,[1]

The head of the radius rested against the lateral part of the trochlea, and the ulna was displaced so far inward that nearly half of the sigmoid cavity projected free beyond the trochlea; upon this free part, and united with it, lay the fractured tip of the epitrochlea.

The *symptoms* of incomplete inward dislocations in the cases which have been described have been, that while the forearm preserved its normal direction with reference to the humerus, the entire lower segment of the limb was displaced to the inner side. This displacement renders the outer condyle of the humerus and its epicondyle more prominent, while the prominence of the epitrochlea disappears. Flexion and extension in the joint have usually been possible, though somewhat restricted. Upon palpation it has been possible to feel the olecranon behind the inner condyle, extending so far toward the inner side as to hide the prominence of the epitrochlea. The external condyle, on the other hand, can be plainly be felt and is unduly prominent, while palpation below it shows that the head of the radius is absent from its normal position below and in front. In some instances the head of the radius has been felt displaced toward the inner side.

Incomplete Outward Dislocations.—In this form the original violence has been similar to that mentioned in the preceding type; but instead of the

[1] L. A. Stimson, *loc. cit.*, p. 626, third edition.

bones being displaced in an inward direction, they are displaced outward. The epitrochlea is torn away from the humerus in a large proportion of cases. The symptoms of the dislocation are thus described by Stimson:[1]

The elbow is somewhat flexed, the angle varying in the different cases, the forearm pronated. The axis of the forearm is sometimes parallel with and external to that of the arm, sometimes adducted. The prominence of the internal condyle is increased and the skin is tightly stretched over it. The transverse diameter of the elbow is increased by the projection of the muscles and the head of the radius on the outer side. Flexion and extension are painful and restricted. In the reported cases no mention is made of lateral mobility.

On palpation the epitrochlea, unless broken off, is very readily felt; if it is broken off, the inner side and edge of the trochlea can be plainly traced, and the epitrochlea may perhaps be recognized as a movable body below it, or it may have been drawn past the edge of the trochlea into its groove where it cannot be felt.

On the outer side the head of the radius projects in a line with the anterior or under surface of the condyle, according as the elbow is more or less flexed. The olecranon is more prominent than normal, because it is lifted out of its fossa and lies against the back of the more prominent external condyle; it is distant from the epitrochlea about two inches. The triceps appears as a prominent cord directed downward and outward to the olecranon. The external epicondyle may be felt by pressing the finger firmly in above the head of the radius and behind the prominence formed by the extensor muscles of the hand.

Complete Outward Dislocation of Both Bones of the Forearm.—This is a rare form, and from the reported cases Stimson was able to collect only twenty-five undoubtedly of this character. The causes have been a fall upon the palm, a blow upon the inner side of the forearm, or a fall upon the elbow. They are grouped by Stimson[2] under three heads. In the first group the bones are displaced directly outward and a little upward; the elbow is partly flexed and the inner edge of the sigmoid cavity rests against the outer surface of the external condyle. The olecranon is behind the epicondyle and the coronoid process in front. The relations of the radius and ulna are preserved. In the second group, which was characterized by Denucé as *subepicondylar*, the forearm is pronated and flexed and the pronation is produced by rotation about the long axis of the ulna, so that the radius lies above or even farther inward than the ulna.

The anterior surface of the ulna looks inward. The head of the radius lies above its normal position in front of the humerus, and possibly still in contact with the upper part of the articular surface of the capitellum.

The third class was called by Denucé *supra-epicondylar*. In this group the elbow is flexed, the radius and ulna are pronated, and both bones are carried upward along the outer border of the humerus.

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[1] L. A. Stimson, *loc. cit.*, p. 635, fifth edition.

[2] *Ibid.*, p. 638, fifth edition.

The sigmoid cavity may embrace the supinator ridge, and the radius still lie in front of the humerus, or both bones may be displaced also backward, so that the coronoid process and the articular surface of the radius are posterior to the ridge.

Having in mind the changed relations of the bones of the forearm to the humerus and the rotation of the former in the direction of pronation, and the possibility of detecting by palpation all the bony prominences of the elbow, in most of the cases, together with the increased transverse diameter of the limb at the elbow, the diagnosis ought not to be very difficult. For further particulars the reader is referred to Dr. Stimson's book, pages 638, 639, and 640, fifth edition.

3. **Dislocation of the Bones of the Forearm Forward.**—This also is a very rare form, less than twenty-five cases having been recorded in the literature. (Stimson.) In seven of these the dislocation was associated with fracture of the olecranon. In addition to the two groups formed by the cases in which the olecranon is, or is not, fractured, a third group is mentioned by Stimson, known as "incomplete," and he distinguishes these from the complete form by calling them dislocations of the *first* and *second degrees*, respectively. In most of the cases the cause has been a fall upon the flexed elbow, a blow upon the back of the elbow, or in others severe forms of direct or indirect violence.

The symptoms and diagnosis are, in a certain number those of fracture of the olecranon with displacement of the bones of the forearm forward. In those not complicated by this fracture, the following data are given by Dr. Stimson: [1]

In five of the cases uncomplicated by fracture it is stated that the forearm was lengthened. The forearm is more or less movable upon the arm. . . . There is flattening of each side and of the back of the elbow, unless the swelling is sufficient to mask it, with prominence of the inner and sometimes of the outer condyle and the formation of a transverse sulcus appreciable by the touch behind between the humerus and the olecranon. . . . The clinical features which differentiate the two forms—i. e., the first and second degrees—are that in the lesser form the olecranon is prominent below the humerus, when the elbow is flexed, and the forearm is lengthened when it is extended or but slightly flexed. In the second, "complete" form, the forearm is more or less shortened when extended, but is lengthened when flexed at or near a right angle, and its antero-posterior diameter is increased because of the projection of the coronoid process in the fold of the elbow. The biceps tendon can be recognized on the outer side of the latter, and beyond it the head of the radius. Posteriorly, in both forms, the olecranon fossa is empty; the direction of the ulna also plainly indicates the change in the position of its upper end unless the swelling is great.

Inasmuch as may of these dislocations have been associated with a compound fracture of the olecranon, the results have not been very good. Four out of seven cases with this complication died.

[1] L. A. Stimson, *loc. cit.*, p. 644, fifth edition.

4. **Divergent Dislocations of the Radius and Ulna.**—These have been extremely rare forms. The displacement may be of two different types. In the one, the ulna is displaced upward behind the humerus and the radius lies in front of the bone of the arm. In the other group the displacement has been transverse, the ulna passing upward to the inner side of the humerus, the radius to the outer side and upward. The degree of violence has usually been severe. The deformity produced by these forms of dislocation would be so unusual and marked that I do not feel that any lengthy description of the signs and symptoms is necessary. All active movements of the forearm are abolished. In some of the cases the displacements have been very marked indeed.

Dislocations of the Ulna Alone

Backward Dislocation of the Ulna.—Dislocation of the ulna alone backward is a rare injury. It is described as occurring in three forms. They are thus defined by Dr. Stimson:[1]

> In the first form, with the smallest amount of displacement, the ulna is carried backward, either directly or by inward rotation of the forearm, about the radius as a center, until the coronoid process has cleared the trochlea, and then is moved slightly upward behind it by adduction of the forearm; in the second form the movement upward is prolonged until the coronoid process lodges in the olecranon fossa; in the third form the primary movement of rotation is prolonged, until the olecranon lies behind the radius. The first form is the most common, and is sometimes termed "incomplete."

Cause.—In the majority of the cases the dislocation has been produced by the same sort of violence which produces backward dislocation of both bones—namely, by a fall upon the extended hand.

Symptoms and Diagnosis.—The limb is held rigidly in extension in the majority of cases, though not in all. The normal valgus position with reference to the upper arm is abolished and for it a varus position may be substituted. Rotation of the radius, however, is preserved and may be painless. The elbow-joint appears thickened from before backward and the flexure of the elbow permits the lower end of the humerus to be seen and felt as a prominence. The radius retains its relations to the humerus and the olecranon may be felt projecting unduly behind. The diagnosis thus presents no notable difficulties upon careful examination. In the third form, of which, according to Stimson, there are but two reported cases, the ulna is dislocated backward and at the same time outward behind the radius.

Dislocation Inward and Dislocation Forward.—Of the former, but one case has been reported, and of the latter but two—namely, by Stimson and Wight.

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[1] L. A. Stimson, *loc. cit.*, p. 650, fifth edition.

Dislocations of the Radius Alone

1. Backward Dislocation of the Radius.—Backward dislocation of the radius is one of the rarer forms. It may be caused by falls upon the hand or upon the elbow, the mechanism of the injury being obscure.

The signs and symptoms are characteristic. The head of the bone can be felt and identified behind its normal position when the elbow is extended, and when flexed at a right angle it can be readily palpated, displaced in a downward direction. Usually the diagnosis presents no difficulties whatever.

Fig. 139. — Outward Dislocation of the Radius in a Child. (New York Hospital, Out-Patient Department, case of Dr. Eugene Pool.)

Fig. 140. — Outward Dislocation of the Radius in a Child After Reduction. (New York Hospital, Out-Patient Department, case of Dr. Eugene Pool.)

2. Dislocations of the Radius Outward.—This form is much more rare than that just described. The diagnosis is to be made by the recognition of the head

of the bone displaced in an outward direction. There is pain and restriction of the motions of pronation and supination immediately after the accident. The ultimate functional result, even though the dislocation remains, is usually good.

3. **Dislocation of the Radius Forward.**—This is much the most common type. The injury has been produced by falls upon the hand, by traction upon the arm, and by direct violence to the head of the bone in a few cases. The diagnosis is usually entirely simple. The forearm is held in the prone position, the elbow somewhat flexed; flexion beyond a right angle is sharply limited mechanically by the impact of the head of the bone against the humerus. The motion of pronation is possible, but supination is limited and painful. On the front of the elbow and upon its outer side the head of the radius may be palpated, and pressure with the finger will show the absence of the head below the external condyle in its normal position.

4. **Subluxation of the Radius in Little Children, the so-called Dislocation of the Radius by Elongation.**—The injury is produced by traction upon the forearm, as when a child is pulled by the wrist to a standing position, or is sharply

FIG. 141.—DISLOCATION OF THE RADIUS FORWARD. (New York Hospital collection. X-ray.)

dragged upward by the wrist to save it from falling, or by some similar act. The condition occurs usually during the first three years of life, and never apparently after the age of six. When the accident happens the child usually cries out with pain, and the arm falls to its side and is not used. Passively, all motions may be made painlessly, except supination. There are no distinct evidences upon palpation of disturbance in the normal relations of the bones, except that the space between the head of the radius and the humerus may be a little increased. Reduction is easy, by forced supination followed by flexion of the joint. The pathology of the condition is believed to be, that by traction the front part of the head of the bone is drawn below the edge of the orbicular ligament.

5. **Dislocation of the Head of the Radius with Fracture of the Ulna.**—The occurrence of this injury and the signs and symptoms which would accompany it have already, incidentally, been sufficiently described. The rather frequent association of these two injuries should lead the surgeon to look for dislocations of the head of the radius in the presence of fractures of the shaft of the ulna and, on the other hand, to exclude fractures of the shaft of the ulna when the head of the radius alone is dislocated.

As a congenital condition, dislocation of the elbow is extremely rare. Stimson believes that in most of the reported cases it is probable that the condition was produced after birth. The elbow is very rarely dislocated as the result of pathological processes within the joint.

OPEN WOUNDS OF THE ELBOW-JOINT

Incised and stab wounds of the elbow-joint as the result of accidents are infrequent. A considerable proportion of the open wounds of the joint are of the contused and lacerated variety and complicate fractures and dislocations of the elbow, either with perforation of the skin by the ends or fragments of the bones, as the result of the same violence which has produced the fracture or dislocation, or perforation may occur secondarily from sloughing of the contused skin.

Gunshot wounds of the elbow-joint constitute a group by themselves having special characters. Soft-lead bullets and soft-nosed jacketed bullets produce upon the complicated structures entering into the elbow-joint the most destructive injuries. They are frequently followed by infection and necessitate in many instances resection of the joint, or even amputation of the extremity. They possess no special diagnostic features which have not been mentioned under gunshot wounds. Wounds produced by shotguns fired at close range are also very destructive when they involve the elbow-joint. They are usually followed by an infection, often of a very severe type, and if the limb is saved, the function of the elbow is often more or less completely lost; a stiff joint or a flaillike joint being the result, according to the lesser or greater loss of substance created by the original injury, or by the necessary operative procedures, such as resection of the ends of the bones, which may be made to meet the indications of drainage, the removal of loose fragments, foreign bodies, etc. All these complicated injuries of the joint are usually easy to recognize, the important features of these cases being, as a rule, the amount of destruction of the bones and soft parts, the subsequent infection and its treatment, and the judgment which the surgeon must exercise in determining what operative procedures are necessary in the given case, and at what time. It is to be remembered in this connection that an ankylosed elbow is most useful when the forearm is flexed to a right angle or a little less and with the hand midway between pronation and supination.

CHAPTER XII

DISEASES AND TUMORS OF THE ELBOW AND ITS VICINITY

THE elbow-joint is affected by the same inflammatory processes which involve other joints, the commonest of these being acute pyogenic infection, which, as already stated, may follow open wounds of the joint, or may occur as metastatic processes in the course of a great variety of general infectious diseases. Among the conditions which may be accompanied by joint inflammation may be mentioned gonorrhea, the acute exanthemata, typhoid fever, pyemia, septicemia, acute osteomyelitis of the humerus or of the bones of the forearm, acute articular rheumatism, pneumonia, syphilis, tuberculosis, and gout. The character of the exudate and the general symptoms produced will vary according to the nature and severity of the infection, as has already been pointed out in Vol. I under Diseases of Joints, and also in Vol. III when discussing Diseases of the Shoulder-joint. (See these headings.)

In the elbow, as in other joints, the characteristic symptoms of inflammation are pain in the joint, rendered worse by motion and diminished by rest. In the elbow the motions of extreme flexion and extension are usually painful and the limb is ordinarily held flexed nearly to a right angle and with the hand moderately pronated. Owing to the swelling of the surrounding soft parts which ordinarily accompanies acute inflammations of the joint, it may not be possible to recognize by palpation the distention of the joint capsule. Tenderness, however, is always to be felt over the head of the radius, and crowding the joint surfaces together is always painful. In some cases in which the intra-articular exudate is considerable in quantity it may, however, be possible to recognize such distention over the head of the radius in front and posteriorly between the olecranon and the radius. Naturally, these signs and symptoms are not in themselves distinctive, and the diagnosis of the exact nature of the process must depend here, as elsewhere, upon other data.

It is to be borne in mind that among the larger joints the elbow is one of those most likely to become ankylosed in a bad position as the result of neglect in maintaining a proper attitude of the limb during treatment.

The elbow is one of the favorite sites of *syphilitic inflammation* of the epiphyseal cartilage in cases of hereditary syphilis among infants. The disease may be followed by separation of the epiphysis; and under these conditions, since the child is totally unable to use the limb, a mistake in diagnosis may occur, in that the limb is believed to be paralyzed (pseudoparalysis syphilitica—

Parrot). (See also Vol. I, page 193.) In some of the cases softening, perforation of the skin, and the formation of syphilitic sinuses may result, sometimes with secondary pyogenic infection. (See also below.)

ACUTE SUPPURATIVE PROCESSES OF THE ELBOW-JOINT

The acute suppurative processes of the elbow-joint, notably when produced by the streptococcus or the pyogenic staphylococcus, are conditions of great gravity. The complicated joint surfaces and the shape of the synovial pouch are such that it is not easy to drain. In many of these cases resection of the lower end of the humerus may be the most conservative and hopeful procedure to be chosen, in preference to amputation of the extremity or death. The indications for active operative interference, other than the mere drainage of the joint, are, evidences of retention of purulent exudate, of perforation of the capsule with burrowing of pus up and down the limb, as shown by a boggy edema and by increased general symptoms of sepsis, and the grating which accompanies movements of the joint when the cartilages are eroded.

Noninfectious serous synovitis of the elbow is common as the result of sprains and contusions. The amount of exudate is rarely so large as to be readily detected on palpation, on account of the swelling of the surrounding soft parts. Here, as in other joints, the nature of the exudate may be safely determined by the introduction of an aspirating needle under due antiseptic precautions.

Even the simple forms of synovitis of the elbow show a strong tendency to the production of adhesive inflammation with resulting stiffness of the joint, more or less marked. There is not the same tendency to recurrence of a simple serous synovitis of the elbow as is to be expected in the knee-joint.

Gout is very rarely localized as an acute process in the elbow-joint. Not infrequently, however, gouty tophi composed of the salts of uric acid are deposited in the vicinity of the joint, sometimes over the olecranon, occasionally within the joint structures themselves, in which case they may give rise to diminution of function, or in other cases be followed by one of the chronic forms of joint inflammation more particularly described when speaking of the shoulder-joint.

CHRONIC INFLAMMATIONS OF THE ELBOW-JOINT

Among these may be mentioned arthritis deformans, syphilitic arthritis of the elbow, and tuberculosis. The destructive lesions accompanying tabes (locomotor ataxia) and syringomyelia are also occasionally observed in the elbow. Those forms of chronic joint disturbance described under Diseases of the Shoulder, and characterized by the production of *floating cartilages* in the joint, are observed in the elbow much less frequently than in the knee. Of all the chronic inflammatory disturbances of the elbow, *tuberculosis* is by far the most important causative agent.

Arthritis Deformans of the Elbow.—While the elbow is a favorite site for ankylosing forms of chronic inflammation, the type which was characterized under Diseases of the Shoulder as arthritis deformans *par excellence* is not very frequent in this joint. It may, however, occur sometimes after fractures involving the joint, or dislocations, or as one of the joints involved in the polyarticular form of the disease which affects especially elderly people and comes on without apparent cause. Here, as elsewhere, the disease is characterized by erosions of cartilage, by bony absorption, by synovial pannus and adhesions, by the production of new bone in the form of osteophytes and of cartilaginous masses along the edges of the synovial membrane, the tendency being always toward ankylosis of the elbow. Arthritis deformans of the elbow is a particularly painful affection, and the patients can be, as a rule, rendered most comfortable by fixation of the joint in a good position, so that ankylosis may be encouraged.

Floating Bodies in the Elbow-joint.—That form of chronic arthritis characterized by hypertrophy of the synovial membrane, and the deposition in its projecting processes of cartilage or of bone, is rather rare in the elbow-joint. In some cases, after fractures of the head of the radius, the loose fragment of bone may remain free in the joint cavity and locate itself either in the olecranon fossa or in front in the coronoid fossa. This condition in itself is sufficient to give rise, if untreated, to a chronic arthritis. The characteristic signs and symptoms of the presence of floating bodies in the elbow are limitations of motion of a definite character. If the body is situated in the posterior part of the joint, the symptoms produced will be a sudden locking of the joint during the motion of extension, accompanied by severe pain. Following the occurrence of such a mechanical locking of the joint by the floating body there may occur an attack of acute synovitis of the joint. Such a history, notably if some fairly severe trauma has preceded, will be suggestive of a loose body in the joint. If the body is of a considerable size, it may sometimes be felt by palpation to one or other side of the olecranon, and if it consists of bone, it may be shown by a good X-ray picture. If of cartilage merely, it cannot. The only treatment for such floating bodies is their operative removal, and an incision into the joint will have to be made, placed according to the situation of the floating body.

Syphilitic Gummatous Arthritis.—Syphilitic gummatous arthritis of the elbow in adults with acquired syphilis may more or less closely resemble a tuberculous arthritis of the joint. The differential diagnosis is, however, generally possible. A syphilitic arthritis will often occur in an individual who appears to be *otherwise in good health.* A syphilitic history is frequently obtainable. The amount of infiltration and swelling of the soft parts about the joint has sometimes been, in the cases I have seen, far in excess of that observed in tuberculosis. The *atrophy of the limb* is, however, less marked in syphilis. The X-rays, moreover, will commonly show in a syphilitic joint, lesions of the bone, if it involve the bones, partly productive and partly destructive. Productive bone lesions scarcely occur as the result of tuberculosis. In the cases *which involve*

the bone the pains are apt to be more or less characteristic of syphilis, in that they are worse at night. Not only is the productive lesion of bone syphilis, when associated with a syphilitc arthritis, noticeable, but also the destructive process is apt to be more extensive than is the case with tuberculosis. The various lesions can best be seen in X-ray pictures.

There occur, however, in the course of tertiary syphilis, chronic inflammations of joints in which the lesion is largely, or for a long time, solely confined to the soft structures. In these the lesion is characterized by thickening of the synovial membrane, with the formation of gummata in its substance, which may soften and open into the joint. As in other forms of productive joint inflammation, a synovial pannus may be produced, and the general tendency of these cases is toward ankylosis. The progress of the disease is very slow; it ends in ankylosis and is usually *less painful* than tuberculosis. It is in these cases especially that a mistake in diagnosis may occur, and a confusion between syphilis and tuberculosis. In some of them no diagnosis will be made unless the joint is operated upon and resected. If gummata exist in the bone, or in the surrounding soft parts, and break down, they will show the ordinary characters of ulcerated gummata in other situations. If the lesion is an old one, it will often happen that these gummata have healed, and the typical circular white, scars left after these lesions may be quite characteristic and suggestive of the nature of the process. At the present time it seems probable that a correct differential diagnosis might be made, in some cases at least, by the Wasserman reaction.

As has been elsewhere stated, in the elbow, as in other joints, there occur, during the early stages of the disease, in some cases, as the first symptoms, before the outbreak of a cutaneous eruption, painful affections of numerous joints, including the elbow—the syphilitic "arthralgia." In hereditary syphilis this painful condition of the joints may be the sole evidence of the disease, or may be a forerunner of the syphilitic osteo-chrondritis, already described. During the secondary period acute polyarticular serous synovites may also be observed. (See Vol. I, pp. 171 and 172.) A valuable aid in the diagnosis is the existence of productive lesions in the long bones in the nature of hyperostosis, producing localized or diffuse enlargements. Such should be sought for in the tibia, the ulna, the radius, humerus, femur, and especially in the metacarpal and phalangeal bones. To reiterate some of the diagnostic features, it is to be borne in mind that the tertiary syphilitic arthridites may be primary in the bones or in the joint structures proper. In the first group the periarticular lesions will be most marked during the early stages. After the joint is invaded there will occur at first a serous synovitis of a subacute or chronic character, with distention of the joint capsule, usually followed later by a papillary synovitis, and this by destruction of the cartilages, fibrous adhesions between the joint surfaces, and a tendency toward ankylosis. In the later stages of this group the diagnosis between it and ordinary arthritis deformans may be difficult or impossible, and the same may be true of those cases

primary in the soft parts of the joint, which early show a tendency toward ankylosis. In the syphilitic lesions, however, the edema of the skin and subcutaneous tissues is wanting; the acute exacerbations of tuberculosis do not occur. As already stated, the pain and limitation of motion are less marked in syphilis than in tuberculosis. The condensation of tissue about a syphilitic joint is, as a rule, much more marked than in tuberculosis. The periarticular structures, though thickened, are firm. In the cases seen during an early stage the effect of antisyphilitic treatment may greatly aid the diagnosis, but, of course, the marked organic changes in the bones and in the joint structures proper cannot be entirely removed by iodid of potassium and mercury. In a certain proportion of tertiary syphilitic joints the destructive process is greatly in excess; thus, gummatous infiltration of the bones, the ligaments, and the cartilages may lead to extensive loss of substance, so that instead of ankylosis the joint exhibits an undue degree of mobility and may thus become quite useless.

Tuberculosis of the Elbow-joint.—Tuberculous arthritis of the elbow-joint is a disease most common in youth, though observed up to middle age and even

FIG. 142.—TUBERCULOUS FOCUS IN THE LOWER END OF THE HUMERUS IN A CHILD. (Author's collection.)

later. More than fifty per cent of the cases occur probably before the age thirty years. The disease is much more often primary in the bone than in t synovial membrane (four to one), and one or other condyle of the lower e of the humerus is infected in considerably more than half the cases. In ma of the remainder the disease is primary in the olecranon. In a few the head the radius is first involved.

The Symptoms and Course of the Disease.—The course of tuberculosis of the elbow is ordinarily slow. A primary focus of tuberculosis may exist for a long time in the bone, and until it invades the joint may give few symptoms. There may be a moderate amount of pain and tenderness over one or other condyle of the humerus, or over the olecranon, for many months, before limitation of motion in the elbow-joint is observed. In favorable cases such foci may be diagnosticated and removed, so that the elbow may be spared. This is, however, even with the aid of the X-rays, a fortunate incident of rare occurrence. While it is quite possible to detect tuberculous foci in the end of the humerus at an early period, it is seldom that the parents bring their child to the surgeon for examination until the elbow-joint itself has been invaded.

The invasion of the joint may be sudden or gradual. In the cases in which a tuberculous focus has undergone caseation and breaks into the elbow by the ulceration of the overlying cartilage, the picture may be that of a rather acute synovitis. In other cases, and these are more frequent, the invasion is slow. The first symptoms referable to the joint are, as a rule, limitation of motion and stiffness on account of pain. The pain is usually first felt when the arm is fully extended. So long as the head of the radius and its surrounding orbicular ligament and synovial membrane remain free, pronation and supination are not painful. As the disease progresses, the characteristic wasting of the muscles of the segments of the limb, above and below the affected joint, takes place. The joint itself exhibits a spindle-shaped enlargement. Nowhere in the body is this typical result of tuberculous joint disease more perfectly shown than in the elbow. The reproduction in the text of a photograph of a negro boy with tuberculosis of the left elbow-joint is a very perfect picture of the condition. In this case the progress of the disease had been rather rapid and was attended by the formation of a tuberculous abscess which ruptured, leaving a sinus behind, also shown in the picture. The characteristic attitude and position of the limb is also present—namely, the patient holds the arm in a position of slight flexion.

Wide motions in either direction become, sooner or later, very painful and finally impossible. The X-ray picture (Fig. 142) shows well the loss of substance on the front of the humerus, just above the elbow, which is observed in certain cases. The patient in this latter case was a little child, and the bones are shown of their natural size. The disease was not far advanced and had scarcely produced any marked external evidences of its presence, except that the elbow could not be fully extended without pain. More than half the cases of tuberculosis of the elbow develop a cold abscess and sinuses, connected usually with one or other condyle of the humerus, or with the olecranon. Occasionally they open posteriorly between the radius and ulna. In case these abscesses do not find their way directly to the skin, they may burrow by gravity down the forearm. In some cases the disease is attended by the production of a large amount of tuberculous granulation tissue, which infiltrates the soft structures

surrounding the joint and forms of a soft and pulpy gelatinous infiltration. In some of these the enlargement of the elbow may be very great.

Primary synovial tuberculosis of the elbow is a much rarer form. König found, among 137 cases, 71 per cent primary in the bones, 29 per cent in the synovial membrane. I have happened to operate, however, upon several of these cases. The disease in the cases which I have seen, showed no very marked

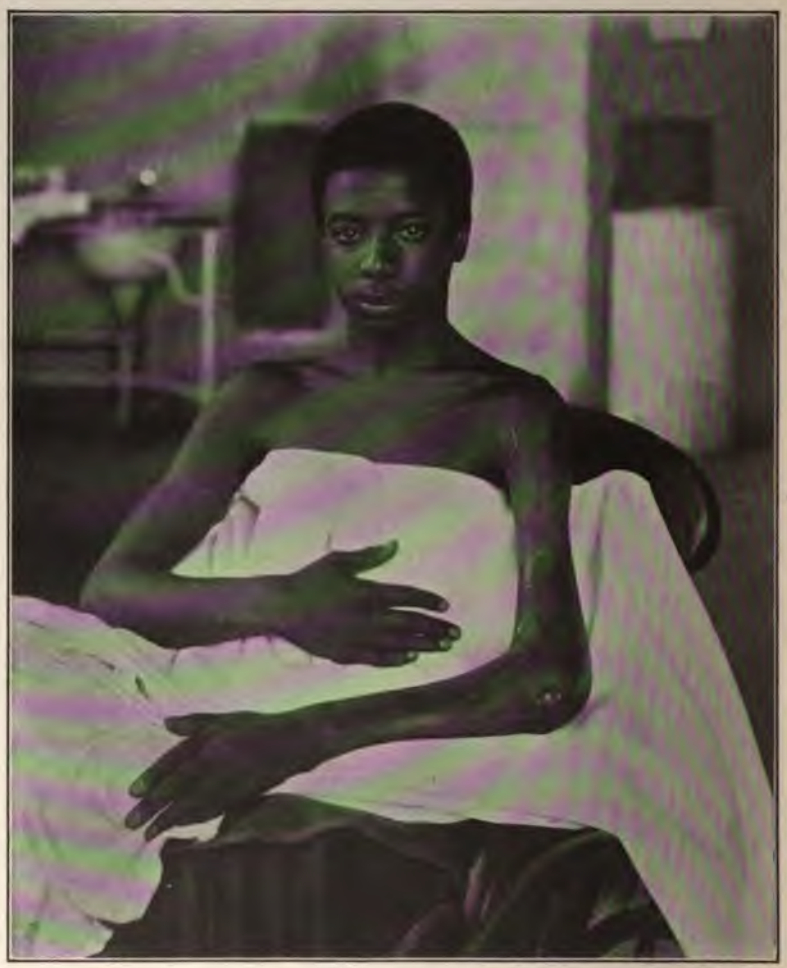

FIG. 143.—TUBERCULOUS ARTHRITIS OF THE ELBOW-JOINT IN A NEGRO BOY. Showing spindle-shaped enlargement of the elbow. Atrophy of the muscles of the arm and forearm. A sinus exists upon the outer aspect of the limb. Duration of the disease said to have been but five months. (Author's collection.)

tendency to caseation and the formation of abscesses. In one, upon which I operated in the Roosevelt Hospital some years ago, the patient was a youth of eighteen. The course of the disease had been very chronic, and when I saw him it had already existed for more than two years. The elbow was greatly swollen.

The atrophy of the limb was rather less marked than is ordinarily seen in the cases primary in the bone. The point capsule was distended in this case to a very large size, so that it formed a fluctuating swelling on the posterior aspect of the limb, which had pushed the tendon of the triceps backward and formed a fluctuating sac of considerable size behind and above the olecranon, across the back of which one could recognize the triceps muscle and its tendon passing downward. There was no notable limitation of motion in this case, nor were the cartilages of the joint eroded to any very marked extent. The synovial membrane was everywhere thickened and infiltrated with tubercle tissue. Its surface was soft, gelatinous, and velvety. Upon operating on this patient nearly a teacupful of rice bodies were removed from the joint cavity. No focus of tuberculosis was discovered in the bones, though the neck of the radius was slightly eroded. The diseased soft parts were dissected out with great care. The only bony part which required removal was the head of the radius. The patient got well, with a movable but not very firm joint, though he was able to perform nearly all motions fairly well.

From the preceding description it may be seen that the diagnosis of tuberculosis of the elbow is, as a rule, not difficult. The youth of the patient, and

FIG. 144.—TUBERCULOUS ARTHRITIS OF THE ELBOW.
(Collection of Dr. Charles McBurney, Roosevelt Hospital.)

the history, together with the limitation of motion, characteristic deformity, the formation of sinuses, the atrophy of the limb, together with the demonstration of a tuberculous focus in one or other of the bones by means of the X-rays, possible in the majority of the cases, render the diagnosis simple.

Prognosis.—The prognosis of tuberculosis of the elbow, assuming that no other tuberculous lesions exist, is fairly good under conservative treatment—namely, fixation of the joint in plaster of Paris in a position of flexion at, or a little less than, a right angle, with the hand midway between pronation and supination. Such treatment, combined with good hygiene, is followed, in a certain proportion of cases, by cure. In others, which do badly or are further advanced when first seen, resection of the elbow, partial or total, is often followed by cure of the tuberculous lesion, with a useful joint.

The injuries of the nerves in the vicinity of the elbow are sufficiently described under Injuries of the Nerves of the Upper Extremity in this volume.

INJURIES AND DISEASES OF THE SKIN AND SUBCUTANEOUS TISSUES IN THE VICINITY OF THE ELBOW

Burns and contused and lacerated wounds of the soft parts about the elbow, with loss of substance, are followed in many instances, after healing, by contraction of the scars, such that serious loss of function in the elbow, forearm, and hand results. The diagnosis of these conditions is to be made by inspection and palpation, and by causing the patient to move the limb so that the extent of the limitation of motion and the depth and attachments of the scars may be determined. The treatment of these conditions is, in the first place, preventive, in that, during the healing of such injuries, the limb should be kept upon splints, which hold it in a suitable position, and that frequent movements of the elbow-joint should be made during the healing process. Further, the treatment consists in plastic operations adapted to the individual case, and to the application of Thiersch's grafts to the raw surfaces when they are in a state of healthy granulation. In some cases flaps taken from the skin of the abdominal wall are useful in closing such defects and diminishing the disability of the elbow and forearm.

Limitation of motion in the elbow-joint may also be caused by wounds and inflammatory processes of the deeper structures, the muscles, the tendons, and the intermuscular planes. In some of these the condition may be improved by passive motion, by division of constricting bands, by plastic operations upon the muscles or tendons, and some are said to be improved by continuous traction. The diagnosis of these conditions, so far as the extent of the disability goes, is easily made, though the exact cause of the mechanical difficulty may sometimes require rather careful study.

The acute suppurative and specific inflammatory processes in the soft parts surrounding the elbow-joint may proceed from infection in the vicinity of the elbow, as, for example, in infection of the bursa which sometimes forms over the olecranon process, or perhaps more often these infectious processes are extensions from infected wounds of the fingers or of the hand. These will all receive especial mention when describing the injuries and diseases of the hand and wrist. In a general way it may be said that here, as elsewhere, such

processes are to be recognized by the local and general symptoms mentioned in many places in this book. (See especially Diseases of Wounds, Vol. I.)

The skin of the forearm or elbow may be the point of invasion of anthrax, of tetanus, of glanders, of hydrophobia, of syphilis and of other specific processes, each of which will give its own characteristic signs and symptoms. The skin of the forearm in the vicinity of the elbow is not infrequently the seat of the tertiary lesions of syphilis, and in this region also there may develop the chronic eczema, followed in certain cases by epithelioma, which is observed as an occupation disease among paraffin workers.

Concerning inflammation of the *olecranon bursa*, it may be said, that the bursa becomes enlarged, forming a rounded elastic swelling over the olecranon, and may from time to time be the seat of a subacute inflammation and finally form a hygroma of considerable size, and this, if infected, may give rise to a localized abscess, or to a spreading infection, as elsewhere described. (See p. 78, Vol. I.) Thus, individuals whose occupations necessitate frequent slight injuries of the elbow are those most likely to develop a bursa over the olecranon. They are miners, stonecutters, mountaineers, butchers who sometimes push away the hide of an animal, in skinning it, with the point of the elbow, and workers in leather who use the elbow for a similar purpose. The condition is very common in the city of New York in dispensary practice among laborers in various occupations.

Occasionally the bursa is infected with tuberculosis and may require removal on this account. It is occasionally, as already noted, the seat of a gouty tophus which may require removal. I have seen a case of this kind in which the tumor over the point of the elbow was as large as a small hen's egg.

Two other bursæ are found near the elbow; one is regularly present between the tendon of the biceps muscle and the tuberosity of the radius. From violent muscular efforts it sometimes happens that this bursa becomes inflamed or filled with blood. It may even be palpable, and under these conditions pronation of the hand will be painful or restricted.

In rare instances a small bursa exists between the tendon of the triceps muscle and the tip of the olecranon. If inflamed, it might give rise to symptoms. Twelve other small bursæ occur inconstantly about the elbow.

As stated elsewhere in this book, during the days when venesection was practiced, frequently by more or less ignorant individuals, a vein at the bend of the elbow was usually selected as a source of blood. If the knife or lancet penetrated the vein, it might readily, and did in some instances, wound the brachial artery at the bend of the elbow. In some of these cases an arteriovenous aneurism was the result. (See p. 332, Vol. I.) Owing to the proximity of the median nerve, pain in its distribution has usually been a marked symptom.

The vessels of the forearm and of the hand have occasionally been the seat of *cirsoid aneurism*. The arteries of the limb are increased in size and become tortuous. In some cases the veins also are involved, and in the nature of the

disease has probably been that of a congenital angioma. The tendency of the condition is to progress slowly. The symptoms have been disturbances of nutrition and of sensation in the limb, with the continuous danger present of serious or fatal hemorrhage from an accidental wound.

As has been already related in Chapter VIII, any of the large nerve trunks may be injured as they pass the vicinity of the elbow-joint, in incised, stab, contused and lacerated or gunshot wounds, as well as in cases of fracture and dislocation involving the elbow-joint. Of the nerves, when injured, the *ulnar* is more often involved than the others. The symptoms have been sufficiently described in Chapter VIII.

A word may here be added in regard to *dislocation of the ulnar nerve.* The lesions of the nerves of the forearm observed in some cases of Volkmann's ischemic paralysis will be mentioned later in the book under Injuries of the Forearm. Some two hundred or more cases of dislocation of the ulnar nerve have been reported. The nerve is displaced forward as far as the tip of the condyle in the majority of instances, very rarely entirely above the condyle. While in some of the cases the dislocation has followed severe injuries, involving fractures at or dislocations of the elbow, in others it has followed blows over the inner aspect of the elbow, which have not produced any other serious lesion. One of the features of the injury is a tendency to recurrence after the nerve has been replaced. In these, annoying symptoms may or may not be produced, and in the former group only is operative treatment indicated. The characteristic symptoms are disturbances of sensation referred to the nerve itself, opposite the elbow, and to its distribution in the hand. The symptoms consist of severe stabbing pain felt in the elbow and in the nerve distribution upon making motions of flexion and extension at the elbow-joint. In many of the cases these pains have been caused by the nerve slipping back and forth over the edge of the condyle as the motions were made. In other cases the pain has been more continuous, and in these, upon inspection, the nerve has been found in a state of chronic inflammation, thickened, sometimes embedded in scar tissue. In addition to the pain, there are subjective sensations of tingling and numbness in the ulnar distribution. In most of the cases, as elsewhere stated, the nerve can be felt as a tender cord passing across or just above the condyle. An ascending neuritis and involvement of other nerves of the brachial plexus may occur. From the preceding description the diagnosis of the condition is entirely simple. (See also Neuritis, Chapter VIII.)

Tumors of the nerves in the vicinity of the elbow have been described in the same chapter.

TUMORS IN THE VICINITY OF THE ELBOW-JOINT

All the forms of benign and malignant new growths have been observed in the vicinity of the elbow. They present the same diagnostic features here as elsewhere. Among the benign forms, osteoma and chondroma may occasionally

develop, usually from or near the line of the epiphyseal cartilages. Other than the symptoms produced by their mere presence, they may cause pain by pressure upon the nerve trunks or mechanical interference with the motions of the forearm. They are to be recognized by their firm attachment to the bone and by the history of a slow growth, a hard, knobby and uneven surface, and by X-ray examination. If the tumor contains bone, or consists partly of bone, it will cast a definite shadow. If it consists of cartilage merely, a faint shadow or none.

The various forms of sarcoma occasionally originate in the vicinity of the elbow-joint. I have seen one or two cases of this kind in which the diagnosis might have been confounded with tuberculosis at the first glance. They were soft and rapidly growing infiltrating forms of sarcoma, which had originated either in the lower end of the humerus or, in one case, in the radius, and had infiltrated the soft parts surrounding the elbow, causing a somewhat fusiform swelling, more or less like a tuberculous arthritis, with periarticular infiltration. Many of the signs, however, of tuberculosis were absent, notably the pain and stiffness of the joint. They were treated by amputation of the arm. *Carcinomata*, with the exception of epitheliomata, originating in the skin, are observed only as metastatic tumors, usually in the bones, in the presence of or after the removal of a carcinoma in some other situation. Here, as elsewhere, the first sign of the new growth may be a spontaneous fracture of one or other of the bones.

CHAPTER XIII

INJURIES OF THE FOREARM

FRACTURES OF THE FOREARM

(See Preceding Chapter.)

INJURIES OF THE NERVES OF THE FOREARM

(See Chapter VIII.)

THE SUBCUTANEOUS INJURIES OF THE SOFT PARTS OF THE FOREARM

THE subcutaneous injuries of the soft parts of the forearm other than the nerves and the blood-vessels present no special diagnostic difficulties. Ordinary contusions produce the same symptoms here as elsewhere, and are followed by swelling, more or less pain and tenderness, by ecchymosis, and, in case the contusion is severe, by injury to the underlying muscles and possibly some loss of function in the motions of the fingers as a consequence. Such accidents, however, not complicated by an open wound or by a fracture, are extremely rare. There is, however, one type of subcutaneous injury of the soft parts of the forearm of rather frequent occurrence and of a very serious character. I refer to Volkmann's ischemic paralysis.

Volkmann's Ischemic Paralysis.—When plaster-of-Paris or other bandages are too tightly applied to a fractured limb and constrict it so that the blood circulation is entirely shut off, the limb becomes gangrenous. The signs and symptoms of such gangrene have already been sufficiently described in Vol. I. (See Gangrene.) If the constriction is not so severe as to stop the circulation in the limb completely, actual gangrene may not follow, but the blood supply of the muscles may be so far diminished as to produce a profound disturbance of nutrition. This affects all the soft parts, but especially the muscles. As a result, the muscle fibers degenerate so that their function is partly, or sometimes totally, abolished. The condition was first described by Volkmann in 1880. Since that time a large number of such observations have been made, though, owing to the fact that the occurrence may reflect upon the skill of the surgeon, comparatively few of these cases are reported. The accident happens most often in cases of fracture of the bones of the forearm or of the lower part of the humerus, much more rarely in fractures of the leg. The lesion is apparently, as stated in Vol. I, a true rigor mortis of the muscle fibers, followed by hyaline degeneration and replacement of the muscle by fibrous tissue. Such

degeneration may be complete or partial, and may involve some or all of the muscles of the limb. In the case of the forearm, the flexor muscles are usually involved to a greater extent than the extensors. The pathological changes in the muscles are due to a great extent to compression of the vessels and consequent impairment of blood supply. The occurrence of the condition is doubtless favored by injury of the blood-vessels, associated with the fracture itself, and by the formation of extensive hematomata around the seat of fracture. The lesion has been observed in cases in which no constricting dressing was applied, but doubtless in the majority of instances the surgeon having applied the dressings soon after the injury, rapid and excessive swelling takes place, so that a dressing which, when first applied, was not too tight, very soon becomes so. The duration of the constriction does not need to be very long to produce degeneration of the muscles; from a few hours to a day is quite sufficent, depending, of course, upon the degree of constriction. In a certain proportion of the cases the destruction of the muscles is complicated by disturbance in the nutrition of the *nerve trunks*, caused usually by pressure or by subsequent involvement in scar tissue. In some of the cases the symptoms of nervous disturbance are very marked indeed, so that not only the muscles of the forearm, but also the small muscles of the hand supplied by the ulnar and median nerves show the electrical reaction of degeneration. That the injury of the nerve trunks is an essential or even a highly important part of the lesion in the majority of instances, seems to me rather doubtful. In some, however, the injuries of the nerves and their involvement in scar tissue during the healing process appears to have been important, since operative interference and dissection of the nerve trunks, placing them in the subcutaneous tissues, thus freeing them from the surrounding scars, has been followed by improvement in a number of instances. (See "Nerve Involvement in the Ischemic Paralysis and Contracture of Volkmann," by John Jenks Thomas, of Boston, *Annals of Surgery*, March, 1909, for bibliography to date.)

Symptoms.—As stated, the patients are usually children who are suffering from a fracture of the bones of the forearm or of the humerus. Soon after the application of the dressing the child will complain of severe pain in the limb, and yet, as was stated when speaking of fractures of the forearm, such is not always the case. Pain there may be, but the patient will not always complain of it, or not complain of it sufficiently to attract the attention of nurses, or even of a nonobservant or careless attending surgeon. If the dressings are not removed, the patient, as a rule, will continue to complain of pain, and by the following day, or even in a shorter time, the destruction of the muscles may be complete. In the meantime the fingers have usually become cold, sometimes blue, sometimes pale. If the splint is removed at the end of, say, twenty-four hours, areas of superficial necrosis will usually be discovered upon the skin where the greatest pressure has been exerted by the dressings. The hand will have already assumed a clawlike appearance and will be in a position of marked or partial flexion. Extension of the fingers, either passive or active, will be found im-

possible. The flexor muscles of the forearm are permanently shortened. The skin bears the ischemia better than the muscles. In other cases the symptoms of disturbance in the peripheral circulation of the fingers will be more marked. Soon after the dressings have been applied, the fingers will become swollen and blue. After twenty-four hours have elapsed they may show evidences of vesication. In a few cases actual gangrene of the limb will occur, and that when the *subjective symptoms* have not been severe.

The degree of contracture of the flexor muscles varies in different cases. In the most severe the fingers will be strongly and immovably flexed into the palm. In others they will be only moderately flexed, and passive extension will be possible. Upon letting go the fingers, however, they at once return to the position of flexion. Accompanying the changes in the muscles, there may be developed, either at once or in the course of days, symptoms of injury to the ulnar or median nerves, or both, evidenced by the signs and symptoms already described in Chapter VIII, when speaking of Injuries of Nerves of the Upper Extremity—i. e., there will be loss of sensation in characteristic areas, together with disturbances of the nutrition of the hand and fingers, glossy skin, and changes in the nails. The fingers will become shiny, shriveled and pointed, and trophic ulcers will develop from slight mechanical and thermal insults.

Diagnosis.—Unfortunately, as may be understood from what has been said, the diagnosis of the condition, if I may use a clumsy witticism, should be made before the condition exists. The contractures are only too easily recognized when once developed, and at this time remedial measures are of very little benefit. The fingers remain flexed, the forearm undergoes a rapid atrophy.

The subsequent treatment of ischemic contracture is rewarded, when conscientiously carried out, by more or less marked improvement. The amount of such improvement depends upon the extent of the original muscle and nerve destruction on the one hand, and upon the intelligence and perseverance with which the treatment is conducted on the other. It consists of massage, the maintenance of the best obtainable position by continuous or intermittent traction upon the affected muscles. I have seen several cases in which the flexed fingers were straightened under general anesthesia; no marked improvement followed. The affected muscles should be encouraged to contract by the daily use of electricity, and both active and passive motions of the joints of the fingers and of the wrist should be practiced with patience and perseverance. The end result will, however, depend largely not only upon the activity of the treatment, but also upon the extent of the original damage. Improvement is reported by Robert Jones and Taylor by prolonged splinting, first of the distal, then of the proximal phalanges, and finally of the wrist.

OPEN WOUNDS OF THE SOFT PARTS OF THE FOREARM

The structures which may be wounded in the forearm, other than the bones, are the muscles and tendons, the blood-vessels and the nerves. In no part of

the body does the intelligent and successful treatment of wounds require a more accurate knowledge of normal anatomy than is the case with the forearm, wrist and hand, nor can such knowledge be properly acquired in any way other than by careful and repeated, intelligently made dissections of the cadaver. In no part of the body, moreover, are serious pyogenic infections followed by more distressing results than in this region. Purulent inflammations of the intermuscular planes and of the tendon sheaths of the forearm are followed by crippling deformities in many cases. Muscles and tendons which have been thus invaded are often rendered either wholly or partly useless. The importance of search for the symptoms of nerve injury in wounds of the forearm has already been sufficiently dwelt upon in Chapter VIII. In treating wounds in this region the strictest attention should be paid to aseptic technic, and the most careful search made for all divided tendons, muscles, and nerves. When the tendons of the forearm are divided near their insertions, whether at the wrist or in the fingers, they retract, often deeply, and rather than leave such tendons unsutured, the surgeon is entirely justified in extending the original wound up and down the limb, no matter to what extent, until all the divided structures have been identified and united. This obtains not only of tendons, but more especially also of *nerve trunks*, and no amount of pain should be spared in recent wounds to identify and unite them suitably by sutures, since, as was pointed out in Chapter VIII, the prognosis for ultimate return of function is far better when such union is made at once, rather than at a later period.

A device sometimes useful when divided tendons near the wrist have retracted deeply into the forearm, is to apply from above the elbow downward an elastic bandage as far as the wound. By this means the tendons may be made to descend and often to protrude in the wound, so that they are readily accessible. The distal extremities of divided tendons, if they be flexors which have retracted into their sheaths, may sometimes be brought to view by flexion of the fingers. If this does not succeed, the orifice of the sheath should be sought for, and the tendon may then be fished for with a slender mouse-toothed forceps, a Kocher's artery forceps, or a small sharp hook. The extensor tendons are usually easier to find than the flexors. The search for the ends of divided nerves is to be guided by a knowledge of normal anatomy.

Division of the radial or ulnar arteries is attended by sharp hemorrhage, which, if uncontrolled, may be fatal. The diagnosis of these injuries is not difficult. The source of bleeding indicates the position of the artery, both ends of which should be tied in the wound. Ligation of the brachial in continuity above the wound is neither necessary nor desirable.

Contused and Lacerated Wounds of the Forearm.—Contused and lacerated wounds may be of any degree of severity. The more serious accidents of this character are often attended by loss of substance in the skin or in the deeper structures, and by extensive scarring and greater or less disability. Such wounds are also dangerous on account of infection, not only with pyogenic microbes, but also with tetanus, the bacillus of malignant edema, Bacillus aërogenes

capsulatus, and other virulent forms. For the diagnosis of these conditions see Diseases of Wounds, Vol. I.

In manufacturing districts many of these injuries are caused by machinery accidents and are associated with fractures, often comminuted, of the bones of the forearm, and very extensive laceration of the soft parts. As stated in Chapter X, so long as the wound can be kept reasonably clean and general sepsis avoided, great conservatism should be practiced. Convalescence in these cases is often delayed by necrosis of portions of bone, and sometimes by failure of union.

Gunshot Wounds of the Forearm.—Gunshot wounds of the forearm possess no special characters not already described under Gunshot Wounds, except that fractures of the radius and ulna with loss of substance and delayed union, or failure of union, are not very infrequent.

CHAPTER XIV

DISEASES AND TUMORS OF THE FOREARM

Acute pyogenic infections of the deeper soft parts of the forearm are very frequent, but since these processes more often originate in the hand than in the forearm itself, the description of them will be given in chapter XVI, Diseases and Tumors of the Wrist and Hand.

DISEASES AND TUMORS OF THE TENDONS

Tenosynovitis Crepitans, Tendovaginitis Sicca.—This is an acute inflammation of the tendon sheaths accompanied by a fibrinous exudate within the sheaths. The inflammation is usually caused by prolonged and unwonted muscular efforts of the hand and wrist. It, in my experience, has been fairly common among blacksmiths and washerwomen. It is also said to occur frequently among drummers—i. e., those who are learning to beat a snare drum. The extensor tendons are usually affected, notably the extensors of the wrist and thumb.

The symptoms of the inflammation are pain on moving the affected tendons and a palpable and sometimes audible *creaking* as the tendons rub against their roughened sheaths. The diagnosis is thus very readily made. The patient comes complaining that the wrist and forearm are weak and painful and that the onset of the condition has followed some hard or unaccustomed hand work. Upon placing the palm of the hand over the affected tendons and requesting the patient to move his fingers, thumb, and wrist, the characteristic creaking is at once evident on palpation. By applying a stethoscope upon the back of the forearm the creaking can be heard. The condition readily subsides under rest and pressure. The hand and forearm may be placed upon a padded palmar splint for a few days and a piece of gauze or cotton may be bandaged firmly along the line of the tendons. Following severe sprains and contusions of the forearm, a more severe type of tenosynovitis may occur such that in some cases adhesions form between the tendons and their sheaths. In neglected cases such adhesions may become so firm that prolonged passive and active motions may be necessary, or even, in some cases, forcible passive motion under an anesthetic will be required to liberate the tendons.

Gonorrheal Tenosynovitis.—The tendons of the forearm and hand, as well as those about the ankle-joint, are occasionally the seat of a gonorrheal teno-

synovitis. This lesion may occur alone or be associated with gonorrheal inflammation of the wrist or of other joints. Following a recent or even fairly remote gonorrheal infection, swelling and edema, sometimes with marked redness of the skin, appears at the site of the inflamed tendon sheaths. Motion, both active and passive, becomes painful, difficult, or impossible. The disease shows a strong tendency to persist in spite of treatment.

Syphilitic Tenosynovitis.—Syphilitic tenosynovitis of a serous type may occur in early syphilis. There will be the history of a recently acquired syphilis, there will be pain on motion, swelling and tenderness over the affected tendons. A gummatous inflammation of the tendon sheaths is observed as a rare condition. The infiltration about the tendons usually subsides rapidly upon the administration of iodid of potassium.

Tuberculous Tenosynovitis.—The sheaths of the flexor and extensor tendons of the wrist and hand are a favorite site for this form of tenosynovitis. The

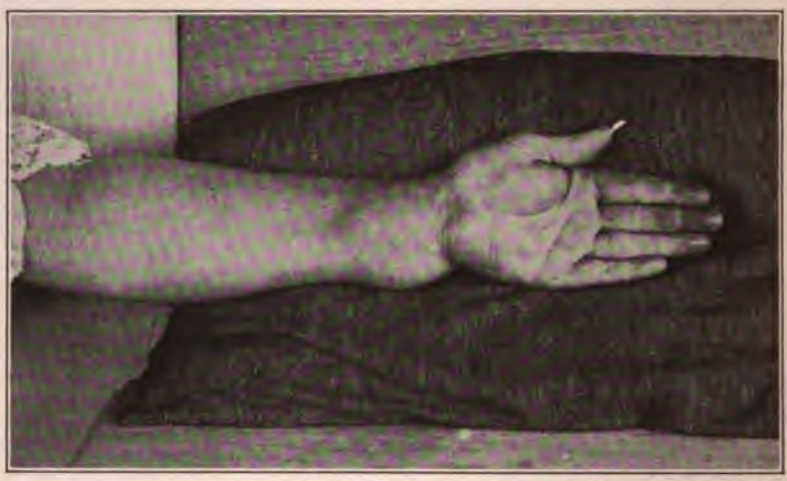

FIG. 145.—TUBERCULOUS TENOSYNOVITIS OF THE WRIST, OF THE CHRONIC NONCASEATING TYPE. A teacupful of rice bodies was removed at operation. (Kindness of Dr. F. G. Beck, of New Haven, Conn.)

disease may be primary in the tendon sheaths, or the infection may be due to an extension from tuberculosis of the wrist-joint, or of the bones of the forearm and hand. For the grouping and pathology of the condition see Vol. I, page 156. It is to be borne in mind when operating upon these cases that not infrequently the primary lesion is in a bone, and that in order to cure the condition it will be necessary to find and remove such a focus. The physical signs of the condition will vary according to the type of the disease. The history is that of a slowly progressive loss of power involving certain motions of the hand and wrist. In the form attended by a *serous exudate*, a generalized, or, more frequently, several circumscribed swellings will be formed along the lines of the affected tendons. If much serous exudate is present, there will be fluctuation. The affection is not notably painful. Marked tenderness is usually

absent. In the form characterized by the production of *rice bodies*, the peculiar soft crepitation produced, as these bodies are squeezed from one dilated portion of the sac through a narrower opening to another part, will render the diagnosis very simple. The flexor tendons are more often involved than the extensors, and in the former cases a swelling is formed above and another below the annular ligament of the wrist-joint. By pressure alternately upon these tumors, the rice bodies may often be felt to slip back and forth from the forearm to the palm. Fig. 145 is a characteristic picture of the condition when far advanced.

In the *fungus variety* a boggy swelling will be formed, and later, if caseation and softening take place, one may find a characteristic tuberculous sinus communicating with the tendon sheaths. This form is often associated with tuberculosis of the wrist-joint and of the lungs, and is a serious and often quite desperate condition. The treatment of all the forms is the same. It consists in the operative removal of the tuberculous granulation tissue by a painstaking, careful dissection. In bad cases it may be necessary to remove some of the tendons. If the condition complicates tuberculosis of the wrist, or of the bones of the forearm, or both, the diseased bone must be removed. Operative cure, even in very bad cases, is possible.

Rupture of Tendons.—In cases of disease of tendons of any kind, whether pyogenic or tuberculous, in tabes, syringomyelia, more rarely in conditions of health, tendons may be ruptured by muscular action. The only tendon of the forearm at all likely to be ruptured in this way is the extensor longus pollicis. The condition has been called "drummer's paralysis." The diagnosis is quite simple; extension of the thumb is impossible, and the outlines of the so-called "anatomic snuffbox"—tabatière anatomique—are abolished.

In cases of avulsion of a finger the tendons are usually torn away from the muscles. This injury will be spoken of again under Wounds of the Hand.

As a great rarity may be mentioned dislocation of tendons of the hand; thus, in the *Deutsche Zeitschrift für Chirurgie*, January, 1092, Haberern reported a dislocation of the extensor tendon of the index finger. In this case the extension of the finger was imperfect and the index finger deviated toward the ulnar side. The displaced tendon could be readily felt. The injury occurred from a fall upon the outstretched palm.

Tumors of Tendons.—The various forms of connective tissue tumor may develop in the tendon sheaths of the wrist. Such tumors are, however, rare. Sarcomata have been observed as well as other forms, the most common being *lipoma* of the tendon sheaths. I have seen a few lipomata connected with the muscles and tendons of the leg and one or two in other situations. They occurred in little children, and from the history appeared to have been of congenital origin.

Lipoma arborescens of the tendon sheaths of the forearm has occasionally been observed. The growths tend to spread up and down the length of the

tendon, or a more or less massive tumor may develop in the palm and thence spread by prolongation, following the tendon sheaths into the forearm. The diagnosis of this last form of growth would scarcely be made before the tumor was exposed by incision, since a chronic tuberculosis of the tendon sheaths, with the production of much tuberculous granulation tissue, would almost exactly simulate the condition.

Of the diagnosis of the *sarcomata* it may be said that their histories in this situation do not differ from those of similar new growths elsewhere. After the tumor has reached a certain size and has infiltrated the muscles and surrounding parts, it is improbable that its exact origin could be fixed.

DISEASES AND TUMORS OF THE BONES

Acute Suppurative Osteomyelitis of the Bones of the Forearm.—The bones of the forearm are among the less frequent localizations of suppurative osteomyelitis of the shafts of the long bones. In the clinic of v. Bruns, among 470 cases of acute osteomyelitis 3.4 per cent involved the ulna and 5.1 per cent the radius. The general and local signs and symptoms of the disease do not vary in the forearm from those observed in other situations. (See Chapter V, Vol. I, page 179 *et seq.*) There will be, together with the signs of general sepsis, severe pain in the affected segment of the limb, loss of function, tenderness, most extreme over the center of the focus in the bone, swelling of the limb from venous obstruction, and, if the patient survive and the periosteum is lifted from the shaft and perforated, the formation of a diffuse suppurative process in the soft parts of the limb. If the lower end of the humerus is the seat of the disease, or the upper ends of the radius and ulna, the elbow-joint often becomes secondarily involved in the suppurative process. If the lower ends of the shafts are affected, the wrist-joint may be involved. The amount of bone destruction, assuming that the patient survives, will depend upon the extent of the infection of the medulla and also upon the promptness and thoroughness of the operative treatment. The separation of the sequestra takes place here, as elsewhere, after a somewhat variable period, but more rapidly than in some of the larger bones, like the femur and the tibia. At the end of from two and a half to three months an X-ray picture, properly taken, will usually show that the sequestrum is in condition for removal. In operating upon the ulna for the removal of sequestra, the bone being throughout so much of its extent subcutaneous, the operative procedures are simple. Such, however, is not the case with the radius. It is crossed by so many important tendons that its exposure without undue traumatism to other structures must be made with care. The shaft of the bone may be approached below the middle of the forearm in the space between the tendon of the supinator longus and the extensor carpi radialis. At the lower end of the radius it is necessary, in exposing the bone, to avoid wounding the extensors of the thumb with the exception of the extensor longus pollicis, which lies more to the ulnar side. In the treatment of those cases of osteomyelitis of the radius

and ulna which survive, early attention should be paid to the preservation and improvement of the functions of the fingers by early passive motion, by changing the position of the fingers frequently, by massage and other devices intended to prevent the formation of rigid adhesions between the tendons, shortening of the muscles, and resulting disability and deformity.

Tuberculous Osteomyelitis of the Shafts of the Radius and Ulna.—Here, as elsewhere, in the long bones, tuberculous foci are more apt to form in or near the epiphyseal ends, rather than in the midst of the shafts. Such invasion of the shafts, however, does occur, usually as a more or less sharply circumscribed process characterized by the history of tuberculosis of bone. The patients are usually children. The progress of the disease is rather slow. The diagnosis is to be made from the signs and symptoms common to tuberculosis of bone. (See Vol. I, page 164 *et seq.*) Fig. 146 in the text shows a tuberculous focus in the ulna of a child with notable bony destruction. It illustrates the clearness with which the diagnosis can be made in superficially placed bones as well as the softening and consequent deformity produced in the bones by the contraction of the muscles. The case came under my observation some years ago. The X-ray picture was taken by me with a tube of very low resistance in order to differentiate to the greatest advantage the structures of the limb, very easily penetrated by the rays in the child.

FIG. 146.—TUBERCULOUS OSTEITIS OF THE ULNA IN A CHILD. (Author's collection.)

Syphilitic Osteomyelitis and Periostitis of the Bones of the Forearm.—The radius and ulna are rather frequent seats of syphilitic inflammation. In some cases the process is a productive one, which begins in the periosteum and is followed by thickening of the affected bone and more or less marked deformity. An early stage of this process is well shown in Fig. 42, page 190, Vol. I. The characteristic bone pains of syphilis are present. In some cases the enlarge-

ment of the bone may be very great. There will be a history of syphilis, the gradual formation of a more or less spindle-shaped enlargement of the shaft of the bone, moderate tenderness merely, but marked pain at night. In cases of doubtful diagnosis it may be said that if the disease is seen during its early stages the use of mercury and iodid of potassium will cause an improvement so rapid as to render the diagnosis of syphilis quite certain. An acute inflammatory process can usually be excluded, from the normal appearance of the skin overlying the enlarged bone. Syphilitic gummatous osteitis of the radius and ulna may go on to softening, the formation of sinuses and gummatous ulcers. (See pages 190 and 191, Vol. I.)

Among *mother-of-pearl workers* an osteoperiostitis of the epiphyseal ends of the radius and ulna is sometimes observed. The disease is attended by enlargements, notably of the lower end of the radius, suggesting the appearance seen in rachitic infants. The chief symptom complained of is pain. The enlargement of bone is usually only moderate.

Tumors of the Radius and Ulna.—While the ordinary forms of benign new growth peculiar to bone, osteoma and chondroma, may develop in the bones of the forearm, much the most interesting tumors of these bones are the sarcomata. The *sarcomata* of the radius and ulna, as is observed of these new growths in other long bones, may originate in the periosteum or in the cancellous tissue or medulla. The periosteal sarcomata are often of the spindle-celled type. Those originating in the medulla of the bones are often giant-celled sarcomata, and in certain cases are not of very great malignancy. The majority of these new growths are best treated by amputation of the extremity. If, however, the tumor is more or less circumscribed when seen, it is possible in certain cases to obtain a cure by resection of the portion of bone affected; a rather risky procedure, nevertheless.

SOME DATA IN REGARD TO THE EPIPHYSES OF THE LONG BONES

The time of the appearance and the dates of union of the epiphyses of the long bones of the skeleton to their shafts are always matters of great interest, both in injuries and in diseases of the bones. The author has seen fit to add a short addendum to this chapter containing some of the data relating to this topic. The study of the bones by means of X-ray pictures has, during the past years, thrown a good deal of new light on this subject. The most careful and thorough work on this topic has been done by John Poland in his book entitled "Traumatic Separation of the Epiphyses," 1898, although there have been other distinguished workers in the same field. The data here presented are derived from the results of Poland's studies. The diagrams in relation to the same matter are from Merkel ("Handbuch der topographischen Anatomie," Fr. Merkel, vol. iii, Part III, 1906.)

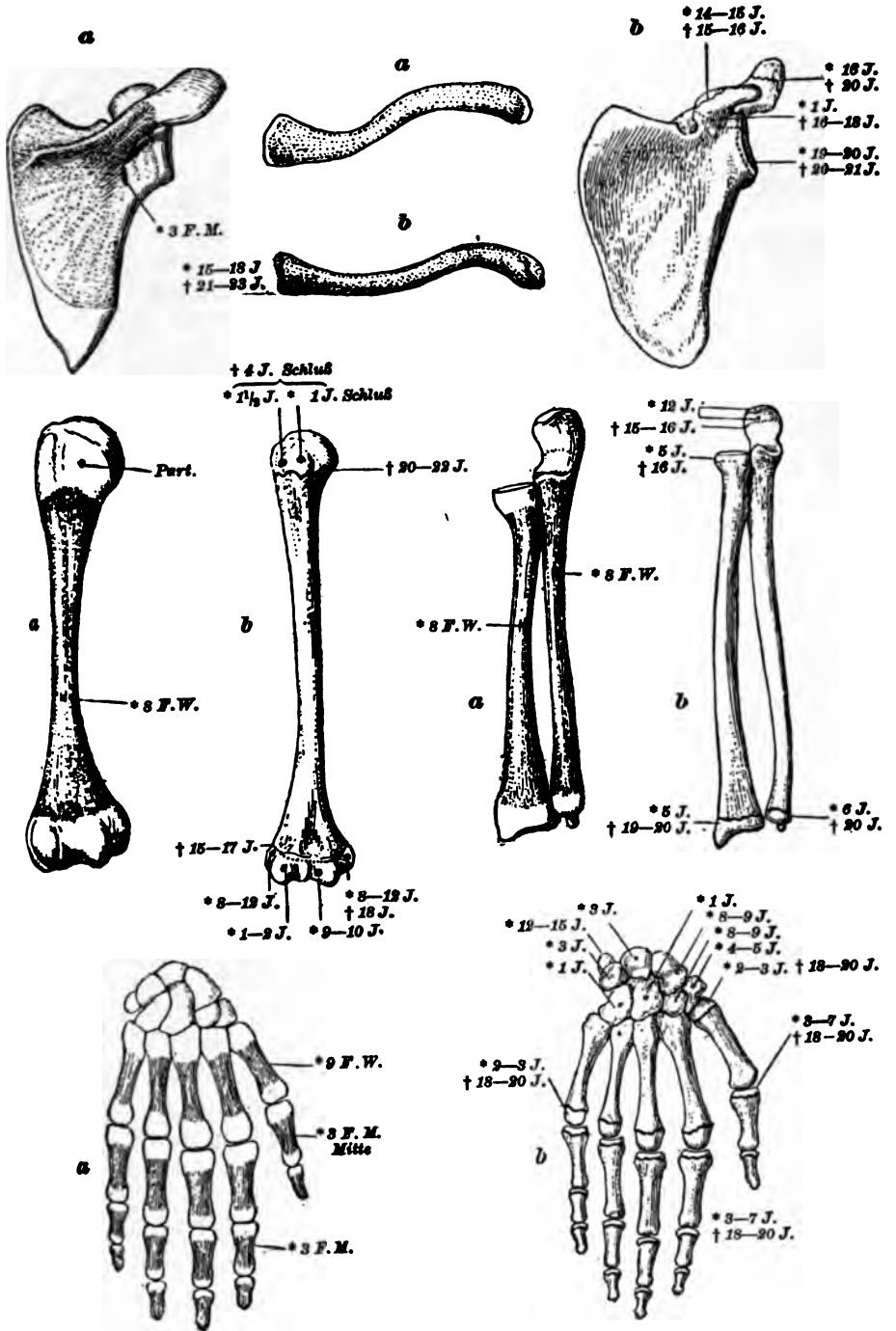

FIG. 147.—DEVELOPMENT OF THE BONES OF THE UPPER EXTREMITY. * Indicates the appearance of a center of ossification. † Union of an epiphysis. *F. W.* Fetal week. *Part.* Time of birth. *F. M.* Fetal month. *J.* Year of life. (After Merkel.)

THE DATE OF THE APPEARANCE OF OSSIFICATION IN THE CHIEF EPIPHYSES OF THE LONG BONES. (POLAND.)

At birth	Lower end of femur. Upper end of tibia.
At one year	Upper end of femur. Upper end of humerus.
At one and one half years	Lower end of tibia. Lower end of humerus.
At two years	Lower end of radius. *Lower end of fibula.*
At three years	Great trochanter of femur. Great tuberosity of humerus.
At four years	Upper end of ulna. *Upper end of fibula.*
From five to six years	Upper end of radius.
At eight years	Lower end of ulna. Lesser trochanter of femur.

Separation of the epiphyses of the long bones occurs, according to Poland's investigations, in the following order of frequency:

1. The upper epiphysis of the humerus.
2. The lower epiphysis of the femur.
3. The lower epiphysis of the radius.
4. The lower epiphysis of the humerus.
5. The lower epiphysis of the tibia.
6. The upper epiphysis of the tibia.

The Upper Epiphysis of the Humerus.—The upper end of the humerus shows three centers of ossification. The center for the head appears at the end of two years; the center for the greater tuberosity in three years; the center for the lesser tuberosity in four years. These three centers unite to form the upper epiphysis of the bone and are joined to the shaft, or diaphysis, at the twentieth year, as a rule, though the union may be delayed four years longer.

The Lower Epiphysis of the Femur.—The lower epiphysis of the femur is present at birth. It shows a well-advanced degree of ossification at the end of three years and unites to the shaft at the end of twenty years, although the union may be delayed for three years more.

The Lower Epiphysis of the Radius.—The lower epiphysis of the radius appears in the second year, and unites to the shaft at the age of nineteen or twenty years.

The Lower Epiphysis of the Humerus.—The lower epiphysis of the humerus exhibits three centers of ossification. That for the capitellum appears in the third year, that for the trochlea appears at the age of eleven, and that for the external epicondyle appears at the age of thirteen. At the end of fifteen years

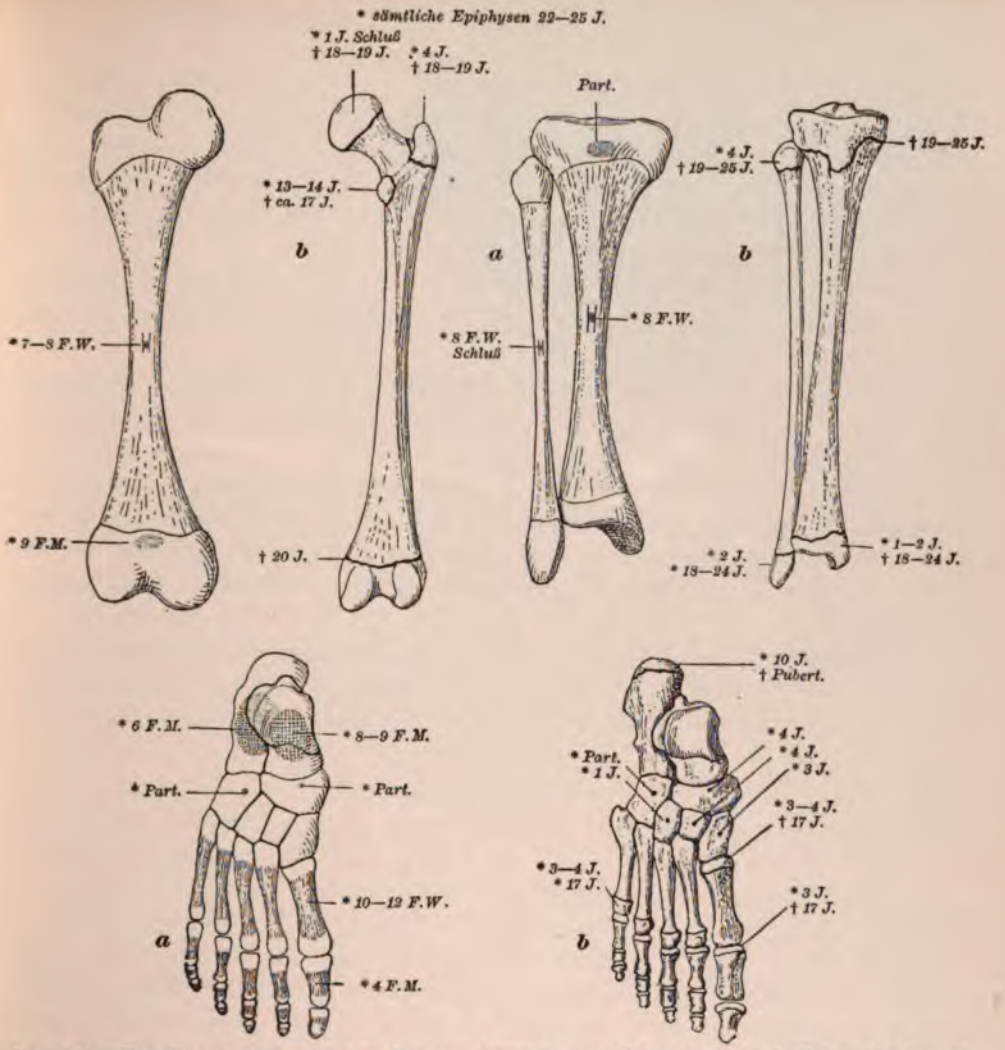

FIG. 148.—THE DEVELOPMENT OF THE BONES OF THE LOWER EXTREMITY. * Indicates the appearance of a center of ossification. † Indicates the union of an epiphysis. *F. W.* Indicates the week of fetal life. *F. M.* Indicates the month of fetal life. *Part.* Indicates at birth. *J.* Indicates the year of life. (After Merkel.)

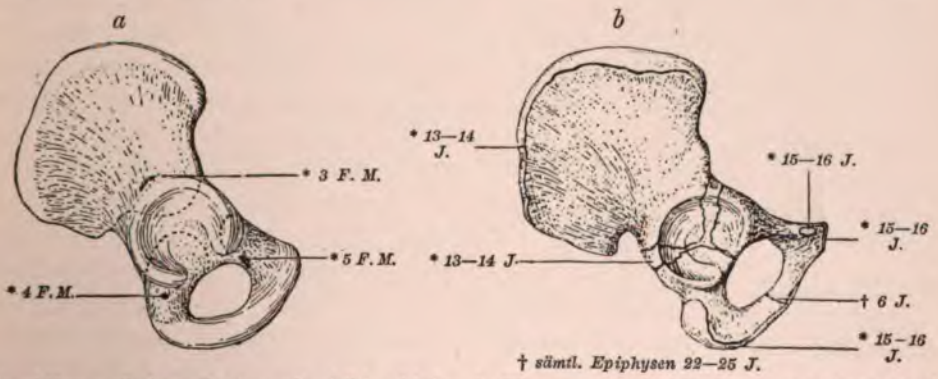

FIG. 149.—*a*. Os innominatum of a child at birth. *b*. The same just before the union of the epiphysis. * Appearance of a center of ossification. † Union of an epiphysis. *F. M.* Month of fetal life. *J.* Year of life. (After Merkel.)

these bony centers unite to form the lower epiphysis of the humerus. This epiphysis unites with the shaft during the seventeenth year. The bony center for the *internal condyle* appears during the fifth year, and joins the shaft of the bone at the age of eighteen or twenty. The epiphyseal line of the lower humeral epiphysis is higher upon the outer side of the bone than upon the inner and passes somewhat obliquely inward and downward.

The Epiphysis of the Lower End of the Tibia.—The epiphysis of the lower end of the tibia appears usually during the second year, and unites with the shaft of the bone during the nineteenth or twentieth years.

The Epiphysis of the Upper End of the Tibia.—The epiphysis of the upper end of the tibia appears about the end of the first year, and unites with the shaft from the twentieth to the twenty-second years.

The Acromion Process of the Scapula.—The acromion process of the scapula has a separate epiphysis which appears at the age of about fifteen years, and unites six or seven years later. This epiphysis includes the articular surface for the clavicle. The epiphysis joins the acromion posterior to the acromio-clavicular joint.

The Fibula.—The center for the upper epiphysis appears during the fourth year of life and unites at from nineteen to twenty-five years. That for the lower end appears at two years and unites at from eighteen to twenty-four years.

CHAPTER XV

INJURIES OF THE WRIST AND HAND

ANATOMICAL REMARKS

(Partly adapted from Merkel.)

It might almost be said that the arm and forearm exist merely for the sake of the hand, since without a hand the arm and forearm are of very little use to the individual. The complicated movements of the hand are rendered possible only by the perfect coördination of a large number of muscles and by numerous bones and joints connected to one another by ligaments, the whole forming the most perfect mechanical instrument known to man. So much depends upon the hand that the loss of a single finger, and more especially of the thumb, may render an individual totally incapable of carrying on his occupation and earning his living in his accustomed way. Though these facts are known to everyone, they are especially important to the surgeon, whose duty it becomes to use the greatest care and conservatism in the treatment of injuries and diseases of this region.

Upon inspection, a large number of interesting anatomical landmarks may be observed upon the hand and wrist, and by palpation many others may be felt. Upon the palmar surface of each finger are to be observed three transverse furrows which correspond to the individual joints. The thumb, on the other hand, exhibits but two. The furrow at the bases of the fingers is not exactly opposite to the metacarpo-phalangeal joints, but is placed distal to the joints at a distance of 12 to 15 mm. The second furrow lies exactly opposite to the joints between the first and second phalanges. The third furrow is not opposite the second interphalangeal joint, but lies from 2 to 3 mm. nearer the hand. The skin upon the palmar surface of the fingers is closely attached to the underlying fat, and from the arrangement of the columns of connective tissue inclosing the fat lobules, these being not parallel with but perpendicular to the surface of the skin, the tendency of infectious processes and abscesses is to spread first into the depths of the finger, whence they readily reach and invade the sheaths of the tendons. Owing to the firm and dense character of the subcutaneous tissues on the palmar surfaces of the fingers, and owing to their extraordinarily rich supply of sensitive nerves, which greatly exceeds that of the skin of the dorsum of the hand and fingers, injuries which cause extravasation of blood into the pulp of the finger, or inflammatory foci which cause tension therein, are exceedingly painful.

Opposite to the interphalangeal furrows the subcutaneous tissues are very firmly attached to the tendon sheaths, so that inflammatory processes in the pulp of the fingers, causing swelling, are often accompanied by an increase in depth of the transverse furrows. Beneath the subcutaneous tissues of the fingers lie the tendon sheaths. Those of the flexor tendons of the second, third, and fourth fingers begin opposite the bases of the metacarpal bones and extend to the bases of the distal phalanges. The tendon sheaths of the thumb and fifth fingers are more extensive. They reach into the palm of the hand, usually as far as the radiocarpal joint, and are in close proximity to the common tendon sheath of the flexor tendons in the palm. In about half the cases they communicate with it. In some instances the tendon sheath of the fifth finger in

FIG. 150.—TENDON SHEATHS OF THE PALM.
a, *b*, *c*. Three common arrangements, see text. (Merkel, after V. Rosthorn.)

the palm embraces also the tendons of the fourth finger, though at the base of the fourth metacarpal bone the flexor tendons of this finger receive a separate sheath. In some cases the two sheaths mentioned—namely, for the tendons of the little finger and for the fourth finger—communicate. In some cases they do not. From these arrangements it may be seen that pus which forms in the tendon sheaths of the thumb, or of the little finger, more readily spreads into the depths of the palm, finally to involve the common tendon sheath of the

flexor tendons at the wrist, and so to reach the forearm, than do inflammations of the tendon sheaths of the second and third, sometimes of the fourth fingers.

The skin of the back of the hand is quite thin and lies in close proximity to the finger joints, so that incised and punctured wounds over the finger joints upon the dorsum of the hand need not be very deep to penetrate into the synovial sacs. The skin of the back of the hand contains numerous hair follicles and sebaceous glands. The skin on the palm of the hand and palmar surfaces of the fingers contains none. Hence superficial skin infections are rather more common upon the back than on the front of the hand.

The extensor tendons of the fingers are plainly visible lying beneath the skin as flat bands. They are connected one with the other by broad fibrous bundles, so that their division is not followed by marked retraction, as is the case with the flexor tendons. The tendon sheaths of the extensor tendons do not reach as far distally as do the flexor sheaths. The extensor tendon of the fifth finger possesses a sheath of its own, which begins nearly opposite the radiocarpal joint and extends distally a little beyond the middle of the fifth metacarpal bone. The common extensor tendons of the second, third, and fourth fingers, as well as the tendon of the extensor indicis, possess a common sheath, with prolongations toward the fingers, which, however, do not reach far beyond the bases of the metacarpal bones. The prolongation for the fourth finger reaches farthest, that for the index finger stops short of the base of the third metacarpal bone. The tendon of the extensor longus pollicis possesses a sheath which extends from just above the wrist down nearly to the middle of the metacarpal bone of the thumb. It may communicate with a small common sheath of the radial extensors of the wrist, though usually it does not. The other two extensors of the thumb possess a sheath in common with separate prolongations upon each. Inasmuch as the extensor tendons do not lie free in their sheaths, but are each more or less bound to the sheath wall by a mesotenon, and since the sheaths are far less extensive than those of the flexors, they are less important as avenues for the spread of pyogenic infections than is the case with the flexor tendons; nor are wounds as common upon the dorsal as upon the ventral surface of the hand.

The normal movements of the fingers vary to some extent in different individuals. At the metacarpo-phalangeal joints voluntary flexion is possible as far as a right angle, and extension to a degree which varies considerably in different cases.

Usually fairly marked hyperextension is possible. In the interphalangeal joints voluntary extension is rarely possible beyond a straight line, though it may be increased by practice. In the terminal joints of the fingers flexion to a right angle is the limit of motion. The thumb exhibits the most complex and varied movements and its loss entails a degree of disability such that for working purposes the hand becomes almost useless. The power of opposing the thumb to the individual fingers is one which makes the human hand an instrument capable of an extraordinary range of usefulness, and this

power being lost, the hand becomes a merely prehensile organ, and not a very perfect one at that. The skin of the palm of the hand is quite firmly attached to the palmar aponeurosis. This is well shown by the puckering of the skin which occurs in Dupuytren's contraction of the palmar fascia. (See below.) Upon either side of the palm and below the wrist there is an eminence, the thenar and hypothenar eminences, respectively. Between them, bounded below by the bases of the fingers, is a hollow, or, in a narrower sense, the palm of the hand. The depression is more marked in muscular, well-nourished individuals and upon flexion of the fingers. The ulnar prominence reaches somewhat higher toward the forearm than that upon the radial side.

Anatomical Landmarks in the Vicinity of the Wrist

The two most useful bony landmarks of the wrist are the styloid processes of the radius and of the ulna. The styloid process of the radius is readily felt if one palpates toward the wrist upon the metacarpal bone of the thumb. The styloid process of the radius extends from a quarter to half an inch lower than that of the ulna. The changed relations of this process in Colles's fracture have already been noted. (See Fracture of the Lower End of the Radius.)

On account of the greater projection of the styloid process of the radius downward, abduction is less extensive than adduction of the wrist and hand. The rounded prominence of the lower end of the ulna is visible and palpable upon the ulnar side. The prominence becomes more marked in flexion of the wrist and varies also among different individuals, being so marked in some that one might think the bone was dislocated. Upon the front of the wrist at its junction with the forearm may be observed several transverse creases in the skin. The lowest and best marked of these passes across the wrist at a distance of about half an inch below the radiocarpal joint (Tillaux). If a line is drawn continuing this crease across the dorsum of the hand, it will cross the neck of the os magnum in the line of the third metacarpal bone. When the wrist is extended a depression exists at this point. When flexed it is changed into a prominence, the head of the os magnum. This crease on the front of the wrist indicates the upper border of the annular ligament and corresponds also to the level of the lower border of the posterior annular ligament. In fracture of the lower end of the radius a slight depression, which normally exists at the bases of the thenar and hypothenar eminences, becomes much more marked and is considered a valuable diagnostic sign of this injury (Tillaux).

About and below the point where the flexor carpi radialis tendon crosses the lower skin crease, a bony ridge can be felt, formed by the tubercle of the scaphoid and the ridge of the trapezium.[1]

Upon the ulnar side on the front of the wrist at the base of the hypothenar eminence can be felt as a rounded nodule the pisiform bone. By grasping it

[1] Woolsey, "Applied Surgical Anatomy," p. 188.

between the finger and the thumb it can be moved a little in its articulation from side to side. If the wrist be flexed, there may be felt quite plainly below the head of the ulna upon the dorsum of the hand a bony prominence, the cuneiform bone.

Upon the radial side of the front of the wrist between the tendons of the flexor carpi radialis and the brachio-radialis can be felt the radial artery. It is here that the pulse is taken and that the educated touch may determine with some degree of accuracy the general condition of the arterial system—i. e., high and low tension, the presence of arteriosclerosis, etc. The artery is here very superficial and is readily wounded. To the ulnar side of the tendon of the flexor carpi radialis lies the median nerve, which is here quite superficial, being covered only by the deep fascia; it is here, as has already been stated, very frequently wounded. If the wrist is moderately flexed and the flexor muscles of the forearm be put upon the stretch, while the thenar and hypothenar eminences are caused to approach one another, a prominent tendon causes a ridge beneath the skin—it is the palmaris longus. The median nerve may lie directly behind this tendon. In some cases the muscle is wanting. On the ulnar side of the front of the wrist the tendon of the flexor carpi ulnaris may be readily traced to its attachment upon the pisiform bone. It may be made more prominent by slight flexion of the wrist. To the radial side of this tendon lies the ulnar nerve and the accompanying ulnar artery. The nerve lies a little deeper than the artery and to its ulnar side. The nerve is often wounded in this situation. The artery and nerve lie covered by the two layers of the deep fascia, but become superficial to the deeper layer just below and pass in front of the anterior annular ligament.

If the thumb be extended and abducted, keeping it as nearly as possible in the plane of the palm, a depression may be observed just above the base of the metacarpal bone of the thumb, below and to the ulnar side of the styloid process of the radius. This depression is bounded by two ridges, upon the ulnar side, by the tendon of the extensor longus pollicis, and upon the radial side by the tendons of the extensor of the metacarpal bone of the thumb and of the extensor brevis pollicis. This depression is somewhat triangular in shape, with its base directed upward, and constitutes what has already been mentioned elsewhere—*the anatomical snuffbox.* The floor of this space contains the radial artery in its passage from just below the styloid process of the radius to the first interosseous space upon the dorsum of the hand, crossing in its course the scaphoid bone and the trapezium. Branches of the radial nerve cross the space vertically and are here superficial.

Upon the back of the radius there exist six grooves for the passage of tendons, which are converted into canals by the posterior annular ligament. The sheaths of these tendons have already been described. The order of the tendons upon the back of the wrist proceeding from the tendon of the extensor longus pollicis toward the ulnar side is, extensor communis digitorum and extensor indicis, extensor minimi digiti, and lastly extensor carpi ulnaris.

In division of tendons upon the back of the wrist by accidental wounds, it is important to bear these relations in mind, so that the distal and proximal ends of each tendon may be identified before suture, and yet here the conditions are much less complicated than upon the flexor surface of the wrist.

The Landmarks of the Palmar Surface of the Hand.—The furrows in the skin of the palm are of interest on account of their relations to deeper structures.

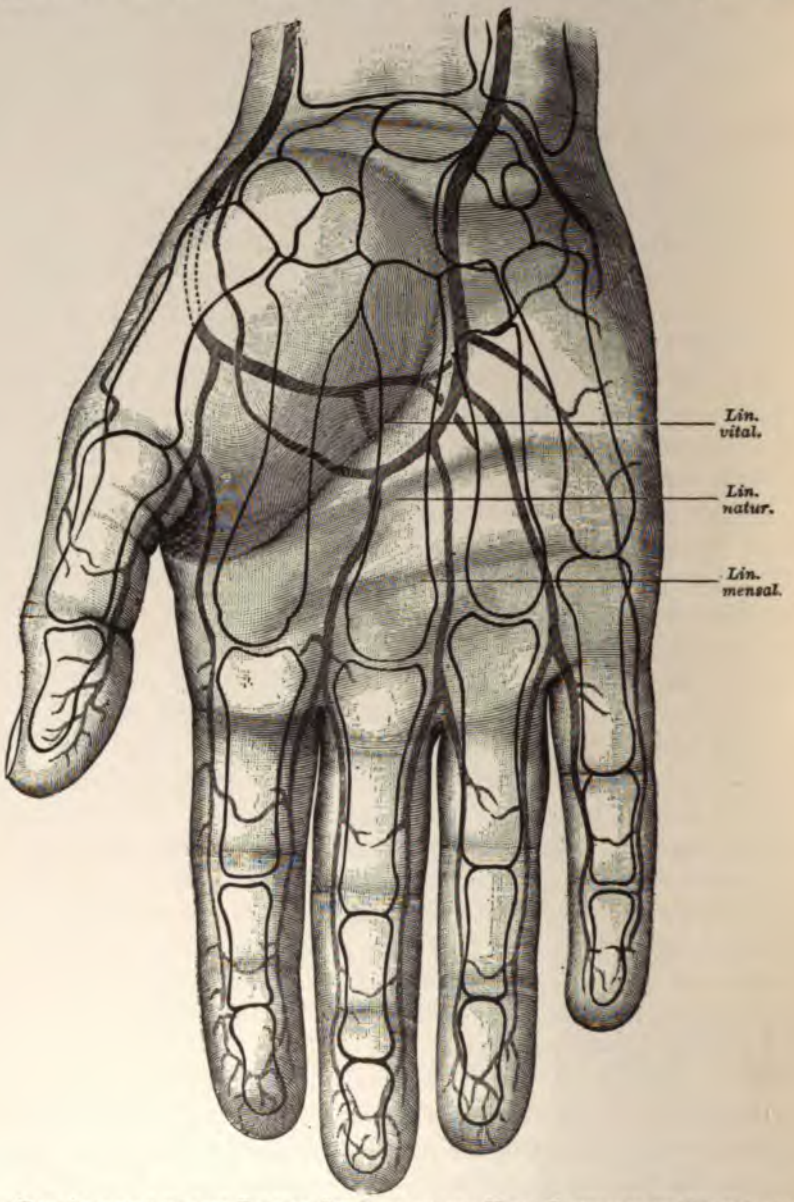

FIG. 151.—THE ARTERIES OF THE PALMAR SURFACE OF THE HAND PREPARED BY SUPERIMPOSING OUTWARD FORM OF THE HAND UPON AN X-RAY PICTURE OF A HAND WITH THE ARTERIES INJEC (Merkel.)

There are three principal furrows. Beginning at the wrist a furrow passes downward in a curve to the radial side, embracing the thenar eminence. The furrow is rendered deeper by adduction of the thumb. It ends at the radial border of the palm opposite the lower end of the metacarpal bone of the index finger. A second furrow starts where the first ends and passes obliquely ulna-

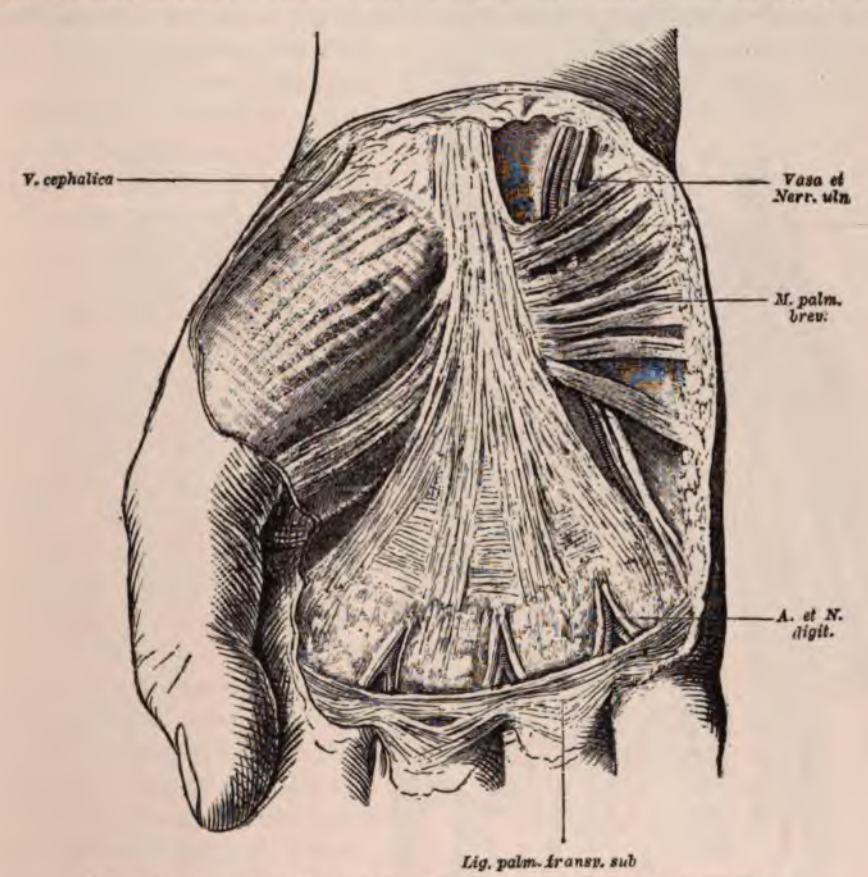

FIG. 152.—THE PALMAR APONEUROSIS, PALMAR FASCIA. (After Merkel.)

ward and a little upward, to end at the edge of the hypothenar eminence. The third and most distal furrow begins at the ulnar border of the hand at the base of the little finger and extends transversely radialward, to end above the interspace between the second and third fingers. The *second fold*, opposite to the middle of the third metararpal bone, is just distal to the lowermost portion of the superficial palmar arch. (See Fig. 151.) The third fold corresponds very nearly with the level of the necks of the metacarpal bones; just below it the palmar fascia divides into its digital processes. The bases of the *first* and *fifth* metacarpal bones are readily palpated upon the dorsum of the wrist. A line joining these two bony points indicates the level of the carpo-metacarpal articulations. The line is slightly concave downward. If the fingers are flexed, the

knuckles, indicating the position of the lower ends of the metacarpal bones, become prominent. By palpation with the index finger the borders of the bases of the first phalanges may be felt. They indicate the lines along which incisions must be made to open the metacarpo-phalangeal joints.

The very dense character of the subcutaneous tissues of the palm and the firm union between them and the skin prevents any very extensive swelling or edema in this region, and, as has already been mentioned, these same characters determine the tendency of pyogenic foci to burrow into the depths of the palm before spreading laterally, as they are then readily able to do.

FIG. 153.—TENDONS AND TENDON SHEATHS OF THE BACK OF THE HAND IN THEIR RELATION TO THE BONES. (After Merkel.)

Upon the dorsum of the hand the skin is movable and lax and wounds here gape much more than upon the palm. Here extensive swelling, ecchymosis, and edema are very common. Large venous trunks are visible upon the back of the hand. They do not exist in the palm. The lymphatics of the palm are, however, very abundant.

The Palmar Fascia.—A triangular-shaped mass of dense fibrous tissue occupies the subcutaneous level of the palm. It is attached above to the anterior annular ligament and to the tendon of the palmaris longus. (See Fig. 152.) It spreads out fanwise below, where it divides into four bundles or slips, which are united to the tendon sheaths of the fingers and send numerous prolongations into the skin. The vessels and nerves for the fingers emerge through the spaces formed by the divisions of the palmar fascia.

A peculiar contracture of the palmar fascia, known as DUPUYTREN'S CONTRACTURE, occurs, usually in middle-aged or elderly men. It involves in the larger number of cases the fascia passing to the fourth and fifth fingers. The

condition may eventuate from trauma, but in many cases no cause can be assigned for it. The contraction is slowly progressive and causes flexion of the first, later of the second phalanges upon the palm. The skin over the affected area becomes puckered and raised into ridges, vertical in direction. These may be seen and felt as hard cords beneath and attached to the skin. The flexor tendons are not involved. Operative cure is sometimes possible by dissecting out completely the contracted fascia. In about half the cases the disease is bilateral. In 263 cases collected by Keen and Nichols the affection was located as follows:

Thumbs	12
Forefingers	24
Middle fingers	93
Ring fingers	249
Little fingers	194

The signs and symptoms of the disease are so characteristic that they scarcely require further mention. The presence of the hard nodules and cords in the palm connected with the fingers, the ability to flex the affected fingers with ease, but inability to extend them completely on account of the dense connective tissue binding them to the palm, the extreme chronicity of the process, the absence of spontaneous pain, all render the diagnosis quite simple.

The arrangement of the palmar fascia is quite important in relation to the spread of infectious processes of the palm. The following description is quoted from Woolsey: [1]

Laterally the palmar fascia is continued as a thinner layer over the thenar and hypothenar eminences. A fibrous membrane connects the deep surface of the palmar fascia, on each side of the central portion, with the interosseous fascia covering the palmar interossei. In this way two lateral (thenar and hypothenar) and a central compartment are formed. Suppuration commencing in any of these spaces may be limited to that space for a time, but the membranous septa are thin and may soon yield. The central compartment is continuous above, beneath the annular ligament, and along the flexor tendons, with the wrist and forearm. It is continuous below with the sheaths of the flexor tendons and the three intervals between the digital slips of the fascia which correspond to the webs between the fingers. Hence pus in the central compartment of the palm makes its way up into the forearm or down along or between the fingers. The resistance offered by the palmar fascia is so firm that rather than perforate it, pus makes its way through the interosseous spaces to the dorsum, though this course is resisted by a layer of fascia covering the deep palmar arch and the interossei muscles. This fascia joins the membranes separating the central compartment of the palm from the thenar and hypothenar compartments in front of the third and fourth metacarpal bones respectively.

[1] Woolsey, "Applied Surgical Anatomy," *loc. cit.*, pp. 195 and 196.

The course and diagnosis of purulent infections of the palm depend largely upon whether such infection is superficial to or extends beneath the palmar fascia. Superficial abscesses of the palm, though painful, remain, as a rule, though not always, localized. Those which form near the bases of the fingers, in the situations where heavy callosities are ordinarily observed upon the hands of working men, are in my experience, if not treated very early by incision, almost certain to find their way through the interspace between the slips of the

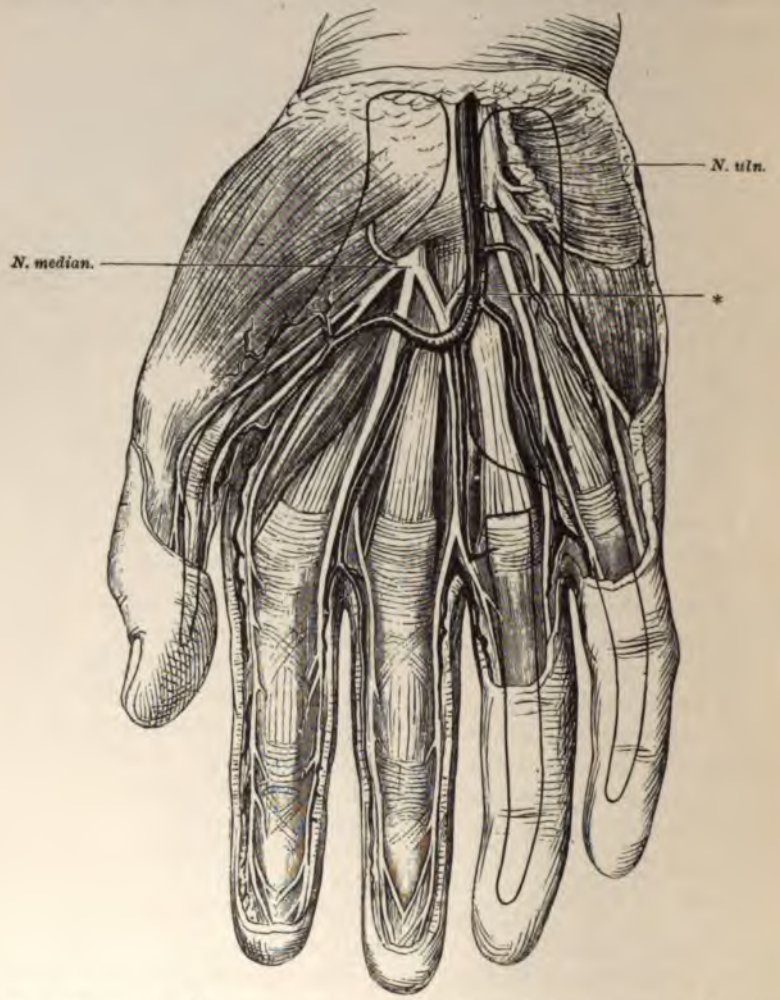

FIG. 154.—THE SUPERFICIAL BLOOD-VESSELS, TENDONS, TENDON SHEATHS, AND MUSCLES OF TH PALM OF THE HAND, TOGETHER WITH THE MEDIAN AND ULNAR NERVES. (After Merkel.)

palmar fascia into the deep structures of the hand. I have seen such infections of the most serious character, take place through a superficial blister of th palm, produced by continuous trauma, as from hard and unaccustomed wor with the hand. When the infection occurs beneath or spreads to the subfascia

structures, the extension of the inflammation may be to the fingers, but it is much more commonly to the tendon sheaths of the palm, thence to the common tendon sheaths of the flexor tendons at the wrist and so beneath the annular ligament to the forearm.

In making incisions in the palm for the evacuation of pus, or for other reasons, the incision should be made in a vertical direction, to avoid injury of the tendons and the digital nerves. The palmar arches should be avoided, if possible; their division during an operation for palmar abscess may be a troublesome accident. The position of the palmar arches with reference to one another, to the bones and to the folds of the palm, is well shown in Fig. 151, from Merkel.

The positions of the palmar arches are as follows: [1]

The superficial palmar arch lies beneath the palmar fascia and superficial to the flexor tendons. Its course is represented by a line, slightly convex downward, commencing at the radial side of the pisiform bone and crossing the palm in line with the palmar aspect of the thumb, when abducted at right angles with the index finger. This line should be avoided, if possible, in incisions in the palm. The deep arch lies about one half inch nearer the wrist, in front of the bases of the metacarpal bones, and beneath the deep or interosseous fascia. It is nearer the dorsal than the palmar surface and is more liable to injury from the former aspect. The bifurcation of the digital arteries occurs about one half inch above the webs of the fingers.

The very varied movements of the hand as a whole are partly accomplished at the wrist-joint and are rendered more free by the movements at the mediocarpal joint. The strongest ligament of the wrist-joint is the anterior one, by which hyperextension is limited. The dorsal ligament of the wrist is thin and not very strong. In disease of the wrist-joint accompanied by an exudate, the synovial membrane may sometimes be felt bulging between the extensor tendons. Such bulging can be demonstrated on the cadaver by injecting the wrist-joint. Ganglion of the wrist arises in some instances from a hernia of the synovial membrane of the joint, forming a small sac upon the dorsum of the wrist near the radial side, which at first communicates with the joint, but later, in most cases, becomes shut off therefrom. Ganglia may, however, in certain cases arise from the tendon sheaths. (See below.)

INJURIES OF THE WRIST AND HAND

By blows and falls upon the hand, various subcutaneous injuries may be produced, which are generally grouped under the head of contusions and of distortions, or sprains of the several joints. They are attended by pain, by swelling, and sometimes by ecchymosis, and by limitation, or temporary loss

[1] **Woolsey**, "Applied Anatomy," *loc. cit.*, p. 197.

of function in certain joints, in the wrist or hand, and may be associated with stretching or partial rupture of ligaments. Very rarely are tendons actually ruptured by subcutaneous injuries, unless the violence has been so extreme as to produce fractures of the bones, or dislocations of the joints.

In examining injuries of the hand and wrist, the surgeon should be extremely cautious about making a diagnosis of a mere contusion or sprain. In an enormous number of cases erroneous diagnoses have been made, in the presence of fractures, notably of the lower end of the radius, sometimes of the metacarpal or carpal bones, or of dislocations. Generally, the part which has borne the brunt of the injury will show the most definite signs and symptoms. If ligaments have been stretched or torn, motions which put such ligaments upon the stretch will be more painful than others. There will be more swelling and more ecchymosis in cases of contusion in the vicinity of the part which has been most seriously injured.

The functions of the several joints should be tested with great care. The hand should be examined for loss of sensibility, indicating injury to nerve trunks. *Points of extreme localized tenderness over bones* should always make the surgeon suspect the presence of fracture. His suspicions will often be verified by an X-ray examination. Where the slightest doubt exists the injury should be treated as a fracture. The functions of the various muscles moving the wrist, hand, and fingers should be tested with care, since though rupture of tendons, or the tearing of tendons away from their bony attachments, are rare injuries, they are serious, or may be so, when they do occur.

When the extensor tendon of a finger is torn away from its attachment to the dorsal surface of the last phalanx, a peculiar condition is produced, sometimes known as "*mallet finger*," or "*drop finger*." I have seen it in several instances after falls upon the hand and fracture of one or other of the metacarpal bones, notably the fifth. In a good many cases, however, the degree of violence producing the injury has been slight and the patient may suffer but little pain. If he be one who is not in the habit of using his fingers for fine work, the injury may be neglected. The symptoms are, loss of power to extend the terminal phalanx of the finger. The last phalanx droops, and cannot be actively, though readily enough, passively extended. A minute fragment of bone may be torn away with the tendon. The treatment is to suture the tendon to the periosteum of the phalanx.

Rupture of the flexor tendons is very much more rare. The rupture occurs at the attachment of the tendon to the terminal phalanx. The symptoms are loss of ability to flex the terminal phalanx of the finger, usually also pain. Since the tendon is apt to retract markedly, it may be troublesome to find. Rupture of the long extensor of the thumb has already been mentioned. Dislocation of tendons, except as a complication of dislocation of the bones, to be mentioned later, is, as has already been stated, a very rare injury.

Division of the Tendons in Open Wounds

These injuries have already been mentioned in several places in this book. Their recognition and proper treatment are, however, so important for the individual that the topic will perhaps bear some repetition. Tendons may be divided in incised, stab, or punctured wounds, and they may also be ruptured or destroyed by blunt violence, as in machinery accidents. The diagnosis of division of tendons is to be made by inspection of the wound under proper precautions and by loss of function in the parts normally moved by the tendon. While the conditions are of easy recognition in most instances, it is surprising how often one sees individuals who have had an incised wound of a finger, or even of the wrist, which has been sutured without attention to divided tendons. In regard to the diagnosis there is but little to be said in addition to what has preceded in speaking of the forearm. Careful inspection of the wound and careful examination as to the function of the various muscles and tendons are necessary for a diagnosis, and these must, of course, be accompanied by a competent knowledge of the normal anatomy and function of the muscles. (See Injuries of the Forearm.)

Fig. 155.—Fracture of the Carpal Scaphoid in a Male Adult. X-ray by the author. (Author's collection.)

Fractures of the Carpal Bones

Since the advent of the X-rays, the recognition of these fractures has been simplified, and whereas formerly regarded as rare, they are now known to be fairly common. As is the case with most other fractures, they occur with greater frequency in men than in women and during the most active decades of manhood. They occur most often from falls upon the hand, and the violence is usually received when the wrist is in a position of dorsal, or rarely of palmar flexion, sometimes combined with abduction or adduction and sometimes with a twist-

ing strain. Injuries to the carpal bones may be associated with Colles's fracture, with fractures of the metacarpal bones, notably that of the thumb, or with dislocations of the wrist, or of other carpal bones. The most complete data upon the subject were published in the *Annals of Surgery*, May, 1905, by Codman and Chase. I am indebted to them for many of the data contained in this section.

FIG. 156.—X-RAY PICTURE OF A NORMAL ADULT WRIST, FEMALE. (Author's collection.)

Fractures have been observed in all of the carpal bones in the following order of frequency: Scaphoid, semilunar, pisiform, os magnum, trapezium, trapezoid, unciform, and cuneiform.

Fractures of the Carpal Scaphoid.—The scaphoid is more often fractured than the other carpal bones. The injury is caused most often by falls upon the wrist, when the hand is in the position of dorsal flexion, rarely in palmar flexion. As a rule, the line of fracture passes through the middle of the bone. (See Fig. 155.) The symptoms are, following a fall upon the extended wrist, pain, swelling of the radial half of the wrist, and limitation of motion in the wrist-joint. Extension is more limited and much more painful than flexion. The effort to extend the wrist is followed by a spasm of very sharp pain. There is always tenderness on pressure over the fractured bone at the bottom of the anatomic snuffbox. The patient may have been treated for a sprain of the wrist; after a few weeks it is observed that while the pain and limitation of motion have diminished to a certain extent, the wrist still remains quite stiff, somewhat swollen, and the motions of extension and abduction of the hand at the wrist-joint continue to be very painful. The examination will show that the styloid processes of the radius and ulna retain their normal relations. Upon attempting to make passive extension of the wrist-joint, the patient will complain of unbearable pain. The radial half of the wrist usually appears

somewhat swollen, or at least thicker than normal. Pressure over the scaphoid bone will elicit extreme pain and tenderness. The diagnosis is to be confirmed by the X-rays and best by stereoscopic X-ray pictures. The marked limitation of motion may remain after fractures of the scaphoid, and if it does not improve at the end of two or three months, it is considered wise to remove the loose bony fragment, inasmuch as in many cases it does not unite with the other, its blood supply having been shut off. One of the most *marked and persistent signs of fracture of the scaphoid* is tenderness over the bone at the bottom of the anatomic snuffbox, and such tenderness may persist, as recorded by Codman and Chase, for years after the injury. Another point which Codman considered important in the diagnosis is the presence of marked effusion into the tendon sheaths of the extensor carpi radialis longior and brevior and extensor secundi internodii pollicis. This effusion may be so marked as to give the sign of fluctuation, in a tense swelling which appears over the radial half of the wrist-joint upon its dorsal surface. The persistence of the limitation of motion and of the tenderness has in certain cases led to the diagnosis of tuberculosis of the wrist, or of a beginning arthritis deformans. The history of the injury, with the characteristic symptoms following it, and the X-rays would usually suffice to eliminate these conditions. Fracture of the scaphoid may be accompanied by forward or backward dislocation of the inner fragment.

FIG. 157.—FRACTURE OF THE CARPAL SCAPHOID. (Case of Dr. Wm. A. Downes.)

Fractures of the other carpal bones are extremely rare. They have usually followed injuries produced by great degrees of violence. The diagnosis is to be made by the history of an injury, by localized pain and tenderness, by limitation of motion in the hands and wrist, more or less marked, and by X-ray pictures.

Dislocations of the Carpal Bones

With the exception of the semilunar bone, isolated dislocations of the several bones of the carpus are very rare injuries.

Dislocation of the Semilunar Bone.—The semilunar bone is sometimes dislocated alone. In many instances the dislocation is associated with fracture of the scaphoid. The bone is most commonly dislocated by extreme dorsal flexion of the wrist. The displacement is forward; at the same time the semilunar is rotated about a transverse axis. The dislocation may be complete or partial. The bone may so far leave its position that it lies in the palm beneath the flexor tendons, or it may even be driven between the tendons and come to lie subcutaneously upon the front of the wrist. The diagnosis is to be made from the history of a suitable injury—namely, a blow or fall upon the wrist in the position of dorsal flexion, by a deformity suggesting the dorsal deformity of Colles's fracture, in some cases. Upon the dorsum of the wrist the os magnum appears to be unduly prominent, notably when the wrist is put in a position of palmar flexion. Just above the prominence of the os magnum a pit or depression may be recognized on palpation, corresponding to the position of the semilunar bone. Upon the front of the wrist a tumor may be recognized on palpation, lying under the flexor tendons. This prominence will present just below the lower end of the radius. The palm of the hand may appear shortened as compared with the uninjured side. The fingers are held in a position of partial flexion, and motions of the fingers, either flexion or extension, are painful. The styloid processes of radius and ulna retain their normal relations.

When combined with fracture of the scaphoid, the fragment of scaphoid attached to the semilunar may share in its displacement. Thus, Stimson says:[1]

> In one of my cases the displacement from the os magnum was complete, but the semilunar could be slipped back and forth upon the radius with loud crepitus. On opening the joint I found a portion of the anterior capsule interposed between the semilunar and the radius, and although I could press it partly out of the way and bring the os magnum, semilunar, and radius apparently into proper relations, they would not remain so. I then removed the scaphoid fragment and again reduced, but the position was still so insecure, the semilunar slipping forward very easily, that I removed it also.

I have seen but one case of uncomplicated dislocation of the semilunar. The case was brought to me for X-ray examination by Dr. John M. Woodbury. The dislocation was recognized by means of the X-rays and was reduced under chloroform by direct pressure upon the palm, while the hand was in a position of dorsal flexion (Codman). The wrist was then flexed and put upon a palmar splint with a pad in the palm. The displacement did not recur, and the patient,

[1] L. A. Stimson, *loc. cit.*, p. 695.

after keeping the wrist upon a splint for a fortnight or more, got a good functional result.

Dislocation of the Scaphoid.—Stimson stated [1] that the reported cases of dislocation of the unbroken scaphoid numbered about ten. The dislocation has usually been backward. The diagnosis could be made by palpating the displaced bone and further by stereoscopic X-ray pictures.

Dislocations of the unciform and pisiform bones have been reported.

Dislocation of the Os Magnum.—Partial and complete dislocations of the head of the os magnum have been reported. They have been produced by external violence and by muscular action. The diagnosis is to be made by finding upon the dorsum of the wrist just above the base of the metacarpal bone of the third finger a bony projection. Disturbances of function in the observed cases have been slight or absent. Stereoscopic X-ray pictures would doubtless show the exact position of the bone quite clearly.

Dislocations at the Mediocarpal Joint.—The joint is formed by the scaphoid, semilunar, and cuneiform above, and by the trapezium, trapezoid, os magnum, and unciform below. These dislocations are so extremely rare that according to Stimson but three cases have been reported all told. One of these was a dislocation backward, and two were dislocations forward, one complete, the other incomplete. Of the backward dislocation reported by Maisonneuve, Stimson says as follows in substance: [2] The hand was displaced backward and was shortened. Posteriorly there projected upon the dorsum a considerable prominence with a depression below it opposite the transverse fold of the wrist. The fingers were flexed and could be extended with difficulty only. The bones of the second row were entirely separated from those of the first and overrode them posteriorly. The internal and external lateral ligaments of the radiocarpal joint were completely ruptured, as were all the ligaments attaching the two rows of bones together. In the incomplete dislocation forward reported by Desprès and described by Stimson, the patient, a man, fell from a swing, his hand being caught between the body and the ground. On the back of the wrist, a finger's breadth below the edge of the radius, there was a depression, below which the wrist and hand were normal in appearance and above which and between it and the radius the finger recognized a distinct bony resistance. The axis of the hand was deviated outward. The dislocation was readily reduced. In the third case, reported by Richmond and described by Stimson, the patient, a man, fell upon his hand from a height of about nine feet.

The hand from the wrist to the knuckles appeared shortened; there was a prominent transverse ridge on the back of the wrist below the ends of the radius and ulna, and below this ridge was a marked depression. On the palmar aspect the base of the hand was unduly prominent, the general direction of the metacarpal bones being quite altered by their bases being pushed toward the palm. Voluntary flexion and extension were lost. The transverse dorsal ridge could be

[1] L. A. Stimson, *loc. cit.*, p. 694, fifth edition, 1907.

[2] *Ibid.*, p. 692.

demonstrated to be the first row of carpal bones with the semilunar unduly prominent.

Dislocations of the Wrist-joint

The Radiocarpal Joint.—Dislocations of the radiocarpal joint are very rare. Formerly, before the nature of Colles's fracture was recognized, this injury was believed to be a dislocation of the wrist. Dislocation of the wrist may occur either forward or backward.

Backward Dislocation of the Wrist.—This has usually followed falls upon the palm of the hand or other violence causing extreme dorsal flexion of the wrist, the violence in many instances having been extreme. Thus, in two cases, those of Bilroth and Ridygier, quoted by Stimson,[1] one patient was pressing with the palm of his hand against a moving railway car when he was struck upon the elbow by another car coming in the opposite direction. He received a compound dislocation of the wrist, the articular surfaces of the radius and ulna projecting through the skin on the palmar surface. The second case was caused in a similar manner between a moving wagon and a wall. In a large proportion of the reported cases the violence has been so extreme that very extensive ruptures and lacerations of the soft parts about the wrist have been

Fig. 158.—Dorsal Dislocation of the Wrist-joint.
(New York Hospital collection, service of Dr. Frank Hartley.)

produced. The tendons upon the dorsum of the hand have been dislocated, and the flexor tendons separated or pushed to the outer side by the radius. The signs and symptoms closely resemble those of Colles's fracture, with, however, certain important distinctions. They are said to be as follows: The projection upon the palmar aspect of the wrist produced by the lower end of the radius is at a lower level than that observed in Colles's fracture, and its lower border is more sharply marked, representing the edge of the radius. The dorsal projection also is more abrupt and it is usually possible to make out on palpation the outlines of the upper borders of the first row of the carpus. In uncom-

[1] L. A. Stimson, *loc. cit.*, p. 683.

plicated cases the relations of the styloid processes of the radius and ulna are preserved; there is notable apparent antero-posterior thickening of the wrist. Generally speaking, there should be no great difficulty in the diagnosis; if complicating fractures existed, or if the limb were greatly swollen, stereoscopic X-ray pictures would render the diagnosis clear. A considerable proportion of the cases are compound dislocations in which the diagnosis could be made at sight.

Forward Dislocation of the Wrist.—In these the cause has usually been a fall upon the back of the strongly flexed hand. Several cases of forward dislocation by direct violence have been reported. There is a marked depression just below the articular border of the radius upon the dorsum of the hand, and the two bones of the forearm project prominently. Upon the flexor surface there is a corresponding projection which is constituted by the displaced bones of the carpus. The motions of the wrist are either abolished or greatly restricted. There is an apparent as well as a measured shortening of the hand from the lower end of the radius to the tips of the fingers. In neither anterior nor posterior dislocations of the radiocarpal joint does reduction present any great difficulty.

Pathological Dislocations of the Wrist.—Pathological dislocations of the wrist-joint as the result of disease of the structures entering into the joint have occasionally been observed.

A spontaneous subluxation forward of the carpus has been observed and reported in good many instances. In some of them the condition has been gradually produced apparently as the result of muscular strains often repeated, of such a character as to tend to displace the wrist and hand forward. In some of the cases observed these strains upon the muscles and ligaments have been entailed by the occupation of the individual; in others no such causative factor could be found. In some cases the condition appears to have arisen without apparent cause, but after it has existed for some time permanent changes in the bones take place, so that the displacement cannot be overcome. Symptoms other than the mere deformity may or may not be present. In some of the cases movements of the joint, and especially the movement of dorsal flexion, have been painful. Among the twelve cases of Madelung, quoted by Stimson, one specimen was obtained from the body of a woman aged about twenty years. Longitudinal sections of the joint were made and showed that the carpal bones were displaced forward, notably upon the radial side, to the extent of half an inch, and to the same distance upward, by absorption of the anterior half of the articular surface of the radius, so that the posterior portion projected downward over the dorsum of the wrist.

Congenital Dislocations.—Congenital dislocations of the radiocarpal joint have been reported—that is to say, examples of congenital deformity of the bones entering into the wrist-joint, such that deformities were produced resembling dislocations. They are of no great surgical interest.

Dislocations of the Joint Between the Radius and Ulna

These may occur in three directions. The ulna may be dislocated forward, or backward, or inward and downward. In fractures of the radius with loss of substance and nonunion, the whole hand may deviate markedly toward the radial side and a subluxation of the lower end of the ulna may thus be produced. (See Fig. 2, page 24, Vol. I.)

Fig. 159.—Fracture of the Fifth Metacarpal Bone, showing Angular Displacement. (Author's collection.)

Dislocations of the Ulna Backward.—In the majority of reported cases the dislocation has been produced by excessive pronation of the wrist. The signs and symptoms are, that the hand is pronated and supination is either difficult or impossible. The ulna projects prominently at the back of the wrist. The dislocation is to be recognized practically at sight.

Dislocation of the Ulna Forward.—Stimson states [1] that this dislocation "appears commonly to have been caused by direct violence coming in opposite directions upon the lower end of the radius and ulna, while the hand was more or less supinated." The signs and symptoms are that the lower end of the ulna forms a prominence upon the front of the wrist and may be displaced radialward, so that it lies more or less in front of the radius. The diagnosis is simple upon inspection and palpation. The injury may be complicated by fracture of the radius.

Dislocation of the Ulna Inward and Downward.—This is usually a complication of fracture of the radius or has been observed as a complication of dislocation of the upper end of the radius.

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[1] L. A. Stimson, *loc. cit.*, p. 680.

Fractures of the Metacarpal Bones

Fractures of the metacarpal bones are fairly common injuries. They may be produced either by direct or indirect violence. In the cases produced by direct violence, blows, or falls upon the hand, or crushing injuries, one or several of the metacarpal bones may be fractured. In the fractures by indirect violence the bone is usually broken by a force which acts in the direction of its long axis, is applied to the head of the bone and tends to bend it, resulting in a fracture. The third and fourth metacarpal bones are most often broken and the two outside ones, the first and the fifth, least often, though the latter are more often broken by direct violence than the former. I have seen recently two cases of fracture of the fifth metacarpal near its lower end. One was produced by a blow with the fist, which fractured the fifth metacarpal just behind the head with slight impaction; the other by a fall upon the hand. This was also slightly impacted. (See Figs. 159 and 160.)

In the cases produced by direct violence, the fractures are often compound and attended by more or less extensive injuries to the soft parts. Such fractures are not infrequently seen in hospital practice as the result of machinery accidents, or the falls of heavy weights upon the hand.

Fig. 160.—Fracture of the Fifth Metacarpal Bone, Dorsal View. (Author's collection.)

The signs and symptoms of fracture of the metacarpal bones are pain and tenderness at the site of the fracture, usually marked swelling and inflammation of the dorsum of the hand, loss of function in the affected finger or fingers, moderate angular deformity visible or palpable, or both, and if the fracture be not impacted, abnormal mobility and crepitation. I have always found that I could make a more accurate diagnosis by means of X-ray pictures than by ordinary methods of examination, except in cases of compound fracture. In some cases in which the signs of fracture have been obscured by swelling, the diagnosis of fracture has been substantiated later by the formation of a pro-

jecting callus. It should be borne in mind that many of these fractures are produced by direct violence with severe contusion of the kunckles and back of the hand, that they are not infrequently compound, or that a small wound or wounds, or abrasions may exist upon the skin over the fracture, that there is a strong tendency for the fractures in this situation to be followed by a sharp attack of inflammation, and that the local conditions favor infection. In such fractures, therefore, precautions should be used to avoid infection. The skin of the hand should be thoroughly disinfected and the severity of the inflammation combated by the application of wet antiseptic dressings, a solution of aluminum acetate for example, and by maintaining as far as possible an elevated position until the inflammation subsides. In fractures of the second and fifth metacarpal bones tight bandging of the hand should be avoided lest by lateral compression it cause an angular deformity.

Fractures of the Phalanges of the Fingers

These fractures may be caused by direct or indirect violence, the former group being much the more frequent. They are caused by external violence, such as blows, falls upon the fingers, are often compound and may, therefore, be serious injuries. In the relatively infrequent fractures by indirect violence, blows and falls upon the end of the extended finger are the most common cause. The symptoms and signs of these fractures are the ordinary pain, mobility, crepitus, etc., and owing to the position and relations of the bones they are easily recognized. In case neither mobility nor crepitation is discoverable, a localized point of extreme tenderness upon pressure and the production of pain when the finger is crowded upward toward the wrist will often indicate the point of fracture. The latter sign is also of value in fractures of the metacarpal bones. In compound fractures caused by direct violence such as are produced by machinery accidents, by blows upon the hand with iron bars, or the falls of heavy weights upon the hand, the injuries are often very complicated and may be attended

Fig. 161.—Fracture of the Base of the First Phalanx of the Fifth Finger, Produced by Striking a Blow with the Fist. (Author's collection.)

by extensive laceration of the soft parts, rupture, or division of tendons, by fractures extending into the joints, and in some cases by such severe contusion of the tissues that the vitality of a whole or portion of one or more fingers may be destroyed. In the treatment of these cases it is to be borne in mind that a thumb, even though much disfigured, or even stiff, may still be a member of great use. The same does not, however, obtain of the fingers. A finger which cannot be flexed may be so much in the way as to be worse than useless. Accordingly, in severe injuries of the fingers, if the probability is that a stiff finger will result from conservative treatment, it is better judgment to remove it at once. If, however, the case is seen soon after the accident, very much may be hoped for by careful disinfection and replacement of the injured parts in their normal relations. If the wound can be kept aseptic, the end results are sometimes surprisingly good. The proximal phalanx is broken more often than the second, and that more often than the third. If, following the healing, the individual finds that the finger or fingers are a detriment rather than an aid to him in his work, such a portion of the finger or fingers may then be amputated as seems best in the individual case.

FIG. 162.—COMPOUND FRACTURE OF THE FIRST PHALANX OF THE THUMB FROM A CRUSHING INJURY. Failure of union. Antero-posterior view. (Author's collection.)

DISLOCATIONS OF THE CARPO-METACARPAL JOINTS

The carpo-metacarpal joints may all be dislocated, either separately or in any combination. The dislocations, however, of all but the first are extremely rare. The dislocations of the metacarpal bone of the thumb are nearly always

in a backward direction. The dislocation may be incomplete or complete, the latter being less frequent. The dislocation may be produced by various kinds of violence. A direct blow or fall upon the ball of the thumb, or by forced flexion of the thumb into the palm of the hand, or by extreme extension. In the incomplete form the base of the metacarpal bone of the thumb forms a prominence upon the radial side of the dorsum of the wrist, rendered more prominent by pressing the thumb toward the palm. It is readily identified as the base of the metacarpal bone by palpation, since it is continuous with the shaft. All the movements of the joint are painful and limited. The dislocation is, as a rule, readily reduced by direct pressure.

In the complete form of dislocation the base of the bone rises up upon the trapezium and the thumb appears shortened. The thumb is usually flexed at

FIG. 163.—FRACTURE OF THE FIRST PHALANX OF THE THUMB BY DIRECT VIOLENCE. LOSS OF SUBSTANCE, FAILURE OF UNION. Lateral view. (Author's collection.)

the carpo-metacarpal joint, and the trapezium can be felt upon the palmar surface of the thenar eminence as a hard body. Reduction has usually been easy by traction and direct pressure. The other metacarpal bones have been very rarely dislocated. When these injuries occur they are to be recognized by characteristic displacements and deformities not hard to identify upon careful examination.

Dislocations of the First Phalanx of the Thumb.—These are interesting and important, since they are not only frequent but also may be difficult to reduce. In numerous instances reduction by ordinary means has failed, and open arthrotomy has been necessary to replace the dislocated bones.

Dislocations of the Thumb

Backward Dislocations of the Thumb.—This is the most common variety and the most interesting. The cause of the dislocation has been blows and falls upon the thumb, producing hyperextension of the first phalanx. The anterior ligament is put upon the stretch and finally ruptures, being torn away from the metacarpal bone. An important element in the dislocation is the fact that the anterior ligament remains attached to the phalanx and is displaced with it. The dislocation may be complete or incomplete. In the latter, the anterior edge of the articular surface of the phalanx rests against the head of the metacarpal bone. In the complete variety the articular surfaces leave one another completely and the phalanx rests upon the dorsal surface of the metacarpal just above its head. In the incomplete form the short muscles attached to the base of the phalanx—namely, the adductor and abductor muscles of the thumb—maintain the phalanx in its position. The terminal phalanx is moderately flexed, the first phalanx hyperextended, but not to a right angle. The dislocation is readily reduced by traction upon the phalanx and flexion of the thumb. This degree of dislocation can sometimes be produced voluntarily by half grown boys and girls through voluntary contraction of the extensor muscles. When I was a boy at school, I recall that the power to produce this dislocation at will was considered a rare and valuable accomplishment.

The Complete Form of Backward Dislocation of the Thumb.—In this form the phalanx is displaced still further upon the dorsum of the metacarpal bone, while the head of the metacarpal projects into the palm and can be felt as a rounded prominence beneath the skin. The phalanx is hyperextended to an extent which may be as great as a right angle. The metacarpal bone is adducted into the palm. Its head projects through the rent in the glenoid ligament, while the tendons of the short muscles of the thumb with their sesamoid bones embrace it upon either side. The tendon of the flexor longus pollicis is usually dislocated to the inner side, though it may remain stretched across the front of the head, or in rare cases pass to the outer side. The internal lateral ligament is ruptured, in some cases the external ligament as well. The phalanx, as it rides upon the dorsum of the metacarpal may be moved laterally, rotated and even flexed so that it lies in a position parallel to the metacarpal. This movement should, however, be avoided, lest by making it, the so-called complex form of dislocation be produced (Farabeuf). He believed that the sesamoid bones might thus be interposed between the phalanx and the metacarpal, rendering reduction difficult.[1]

The cause of this difficulty in all cases in which I have exposed the joint has been the torn edge of the anterior ligament closely drawn across the back of the metacarpal behind its head, and a slight nicking of that edge made reduction easy.

[1] L. A. Stimson, *loc. cit.*, p. 707.

It is believed that flexion of a dislocated phalanx tends to produce this engagement of the capsule, but I know that it can take place without that aid.

In attempting to reduce these dislocations of the thumb, traction in the straight position should not be used, for under these circumstances the muscles attached to the sesamoid bones pull the glenoid ligament backward, so that when the attempt is made to bring the phalanx back into place by traction followed by flexion, the ligament comes to lie between the joint surfaces, its anterior face being applied to the head of the metacarpal bone. According to Stimson: [1]

The attitude of the thumb is maintained by the short muscles attached to it, and all that is necessary to overcome that opposition is to relax the muscles by pressing the metacarpal bone toward the palm, then reduction is made, while maintaining the phalanx in rectangular dorsal flexion, by pressing its base downward toward the end of the metacarpal and flexing when the proper level is reached. If the torn anterior ligament has not caught behind the head, as just described, it will be pushed before the base of the phalanx and the latter will turn past the head of the metacarpal in flexion as soon as it descends far enough.

If the ligament has caught behind the head it renders reduction much more difficult. If pressure upon the base of the phalanx is continued in the extended position, while at the same time the phalanx is rotated, the ligament may sometimes be disengaged from the head, when reduction will occur. If not, an open operation is better than undue violence.

Forward Dislocations of the Thumb.—These are produced by a blow or sudden pressure upon the dorsum of the first phalanx producing an extreme degree of palmar flexion. The injury is a rare one. The signs and symptoms are that the phalanx is displaced forward, that the metacarpal projects prominently upon the back of the thumb where it may be seen and felt. Reduction is easy by traction and forward pressure upon the metacarpal with backward pressure upon the phalanx, or, according to Stimson, by forced flexion of the thumb aided if necessary by impulsion downward of its base.

Dislocations at the Metacarpo-phalangeal Joints of the Fingers

These are far less frequent than corresponding dislocations of the thumb, dislocation of the index finger being the most common. The dislocation may take place forward or backward. The causes are blows or falls upon the finger causing hyperextension. The joint capsule is torn away anteriorly from the head of the metacarpal. The diagnosis is simple. In dorsal dislocation the base of the phalanx forms a prominence upon the back of the hand. The head of the metacarpal projects into the palm. The finger may be straight or slightly flexed. There is loss of function in the finger which appears shortened. In the incomplete form, reduction is easy by traction followed by flexion. In

[1] L. A. Stimson, *loc. cit.*, p. 707.

the complete form this method commonly succeeds but may fail. Stimson recommends in preference to these manipulations direct pressure upon the base of the phalanx with the finger in hyperextension followed by flexion; believing that the difficulties met with in reducing these dislocations depend upon the interposition of the anterior ligament in the form of an apron between the head of the metacarpal and the base of the phalanx. Cases in which the obstacle was of this character have been reported by Willimer, König, Lange, Volkmann, and Stimson. In one case of my own, a dorsal dislocation of the first phalanx of the fifth finger in a young woman, reduction by manipulation failed. I made a small incision over the palmar aspect of the joint and found that the obstruction was due, in part at least, to interposition of a heavy strand of the anterior ligament interposed between the head of the metacarpal and the base of the phalanx. The flexor tendons were found displaced to the radial side of the metacarpal and were wound across the side of its head and upon its dorsum. The dislocation could not be reduced until the tendons were disengaged from between the bones and replaced in front of the metacarpal by means of a hook, when reduction was readily made.

Forward Dislocations of the Metacarpo-phalangeal Joints.—These dislocations are produced by notable violence to the fingers. Stimson states that their mode of production is not clear. They are readily recognized by the projection of the head of the metacarpal upon the dorsum, and the projection of the base of the phalanx into the palm where it may be felt. Reduction is easy.

Dislocations of the Phalanges of the Fingers

Dislocations of the Middle Phalanges of the Fingers.—These may occur from blows or falls upon the fingers. The distal phalanx may be displaced forward, or backward, or rarely to one side. They are easy to recognize upon inspection and palpation by recognizing the bony displacements.

Dislocations of the Distal Phalanges.—These are usually backward, forward dislocations having been observed in the thumb only. The cause is a blow or a fall upon the end of the finger. Recognition and reduction are usually easy. If the violence was extreme the tendon of the flexor may be torn away from the base of the phalanx or the dislocation may be rendered compound. Stimson stated [1] that while the reduction is usually easy, it may be rendered difficult by the interposition of the anterior portion of the capsule, or by the tension of the displaced tendon, as he has observed in compound dislocations of the terminal phalanx of the thumb so that the tendon had to be drawn aside with a hook in order to reduce. There is nothing characteristic about the position of the phalanx. It may be extended or straight, or flexed across the articular surface of the phalanx above.

Forward dislocations of the terminal phalanx have been observed only in

[1] L. A. Stimson, *loc. cit.*, p. 713.

the thumb. The diagnosis will be simple upon inspection and palpation. Lateral dislocations are extremely rare.

Open Wounds of the Hand and Fingers

While the diagnosis of open wounds of the hands and fingers is usually quite simple, upon careful inspection of the wound, yet there are so many important structures which may be wounded and so many serious and even fatal complications which may follow wounds of the hand, that these injuries deserve the most careful scrutiny. It is to be borne in mind that the vitality of the hand and fingers is very great and that the most complicated injuries, if they can be kept clean, heal quickly and well. The hand and fingers are, however, exposed to a great variety of infections, and a comparatively trifling wound in this region may be followed by disastrous and even fatal results. One of the most common complications of small and apparently trifling wounds of the hand is the division of a tendon. The possibility of such an injury should always be thought of. Such is the abundant blood supply and vitality of a finger that in case a portion of a digit is actually severed and the wound is seen within a very short time of its infliction, the separated part should be sutured in place in the hope that it may survive. Other common accidents in wounds of the hand are injuries of joints. I have seen such occur in dispensary practice, not infrequently at the metacarpo-phalangeal joint in consequence of a blow of the fist striking against a sharp tooth. Such an injury may be very serious indeed. Early and careful disinfection may render it aseptic, but in numerous instances the joint becomes infected and a stiff joint or amputation of the finger is the result. I have several times seen a chancre of the finger or knuckle result from a blow with the fist against the tooth of an individual with active syphilis and mucous patches.

Penetrating wounds of the finger-joints may usually be recognized by the escape of a small amount of synovial fluid. When infection of the wound occurs, the joint becomes exquisitely painful, the surrounding soft parts are swollen, notably upon the dorsal surface. The discharge is changed from a clear synovia to a sticky purulent one. Crowding the joint surfaces together is exquisitely painful. Erosion and destruction of the cartilages are readily recognized by bony grating on motion.

In the treatment of all injuries of the finger and hand, however, it is to be borne in mind that fibrous ankylosis with permanent stiffness may result, notably in elderly people, if the joints are kept in one position too long. Therefore, in hand injuries in general, it is wise to leave the fingers so exposed that they can be moved, if that is possible, or if not, to begin passive and active motions in the finger-joints at the earliest possible moment.

Foreign bodies in great variety may penetrate and remain in the hand or fingers. Such may be needles or parts of needles, bits of steel, bullets, pieces of glass, splinters of wood, etc. At the present time, such bodies, if inorganic,

can readily be detected and located by means of stereoscopic radiographs. The position of the foreign body with reference to bone, whether upon the dorsal or the palmar aspect of the same, can be determined in this way with accuracy. This is of course not true of pieces of wood or other organic material. In the absence of an X-ray examination, sharp and slender foreign bodies like needles, which have penetrated the hand, should never be sought for in a haphazard fashion. Such bodies may often travel a considerable distance in a few days, and unless they can be actually palpated, or recognized as giving a sense of resistance, the surgeon should be very cautious about cutting for them. I have seen numerous futile attempts of this character. In the detection of such a foreign body, however, an important diagnostic aid is the finding of some *fixed point of tenderness* when the finger or hand is pressed upon or grasped in a certain way. If the examination be made persistently and carefully, one may thus be able to locate a foreign body with reasonable certainty, so that an incision will be justifiable.

FIG. 164.—GUNSHOT FRACTURE OF THE FIFTH METACARPAL BONE, SHOWING SMALL FRAGMENTS OF LEAD; UNION WITH SHORTENING. (Author's collection.)

The ordinary pistol-shot wounds not infrequently seen of the hand are, if the wound is not probed or otherwise infected, and if no bone is fractured, rarely of great gravity. An exception must be made, however, in the case of the blank-cartridge pistols commonly used by boys on the fourth of July and other jubilant occasions. The wadding of such cartridges is often infected with tetanus germs, and, as already mentioned in this book, numerous cases of tetanus are observed nearly every year during the weeks following the fourth of July. It is wise and proper in these cases to give a prophylactic injection of tetanus antitoxin and to disinfect the wound thoroughly. If bullets or other foreign bodies give evidence of their presence by irritation of nerve trunks, they should be removed at once, lest a neuritis develop. In the X-ray picture of a

girl's hand shown in the text (Fig. 164) persistent and annoying pain in the distribution of the ulnar nerve had been occasioned by the minute fragments of lead shown in the picture.

The diagnosis of wounds of the palmar arches is usually not difficult from the active hemorrhage. In wounds of the palm, the superficial palmar arch, the position of which is shown in Fig. 154, is most often wounded; the deep palmar arch is nearer the dorsum of the hand and may be wounded by a cut or stab which passes between the metacarpal bones, between the first and second, or second and third fingers. While hemorrhage from these vessels can sometimes be stopped by pressure it is to be borne in mind that if the pressure is too violent, or too prolonged, it may lead to sloughing, or possibly to gangrene of a portion of the hand.

FIG. 165.—CICATRICIAL DEFORMITY OF THE WRIST AND HAND FOLLOWING A BURN. (New York Hospital collection, service of Dr. F. W. Murray.)

Incised or stab wounds may also divide one or other of the branches of the *median or ulnar nerves*, and when wounds are so situated as to render this accident probable, areas of anesthesia should be sought for, and if found, the divided nerve should be sutured if possible.

As the result of scars, crippling deformities in great variety may occur. Such scars may be the result of ordinary burns or scalds, or of wound infections, or of injuries with loss of substance. Peculiarly severe burns are observed as the result of contact with live electric wires bearing a current of high voltage and large ampèrage. These electric burns are frequently very deep, involving the soft parts and including also the bones, so that highly destructive lesions and crippling deformities result. These burns are notably painful, and unless infected, repair takes place after the separation of the sloughs in the ordinary way, but in the cases seen by me in the New York Hospital the reparative process has been slow. The appearance of these burns is more or less characteristic. At the line of contact of the wire upon the skin there is a narrow and usually blackened sulcus. The skin on the borders of this area appears whitened and is deprived of its vitality. Frequently the depth of the

destructive lesion is much greater than would appear from observations made immediately after the injury. If the voltage has been very high and the ampèrage abundant, as ordinarily observed in commercial street circuits, a fatal result may be produced without any very marked local lesions. Induced currents and alternating currents are more dangerous and destructive as a rule than direct currents. Much depends also upon the completeness of the

FIG. 166.—CICATRICIAL DEFORMITY OF THE INDEX FINGER FOLLOWING A BURN.
(New York Hospital Out-Patient Department.)

contact. If the voltage be very high and the ampèrage small, a current may be received through the body without notably destructive effects. If, on the other hand, though the voltage be but moderate, the ampèrage is large and the contact good, death, or in other cases very severe burns, will be produced. The effects in these cases will vary according to whether the current passes through a finger or the hand merely, or, on the other hand, through the head or trunk, the latter conditions being more favorable for the transmission of sufficient current through the central nervous system, or the heart, etc., as to produce death. A very moderate amount of current indeed which is actually driven through parts of the body containing vital organs will be fatal.

The peculiar changes observed in the hands and fingers as the result of trophic disturbances following injuries to nerve trunks are described under Injuries of the Nerves of the Upper Extremity, Chapter VIII. See also in the same chapter Traumatic Neuritis.

Following contused wounds and contusions of the bones of the hand a subacute periostitis is sometimes observed. It is sufficiently described in Vol. I, page 187.

CHAPTER XVI

DISEASES AND TUMORS OF THE WRIST AND HAND

DISEASES OF THE SOFT PARTS OF THE WRIST AND HAND

Acute Inflammatory Processes of the Hand and Fingers.—As already indicated, the hand is constantly subjected to traumatisms of greater or less severity and is, moreover, exposed to contact with infectious materials to an extent which does not obtain of any other part of the body. Consequently inflammatory processes of the hand are frequent. They are, moreover, highly important since infections of the hand, followed by suppuration, often become generalized with the production of severe septic infections and of septicemia and pyemia. Moreover, the local effects of suppurative processes in the hands and fingers are very important since they often result in permanent disturbance of function and consequent disability.

Acute Abscess of the Fingers and of the Palm—Whitlow, Felon.—Acute abscesses of the finger are due to infections of wounds in the skin of the fingers by one or other of the pus-producing bacteria. Hematogenous infection is also possible. The wound may be of any degree of severity from a considerable incision or laceration of the skin, to a needle prick, or to the minute cracks and fissures which form around the base of the nail, to the trifling loss of substance in the cuticle caused by pulling off a so-called "hang nail," or the like. The pyogenic infection, as has already been indicated elsewhere, tends in the pulp of the finger to invade the deeper structures rather than to spread superficially. Thus, not only the skin and subcutaneous tissues, but also the tendon sheath of a finger, the periosteum of a phalanx, or the phalanx itself may become the seat of suppuration from a trifling superficial infected wound. The results in the given case will vary greatly and that often without assignable cause. In one, the abscess formed may remain confined to the skin and subcutaneous tissues of a single phalanx and be incised, or more rarely rupture, and get well without serious constitutional disturbance, and without much local destruction of tissue. In another case in which the conditions of infection appear to be identical with the first, the pus will rapidly spread to the tendon sheath of the finger and thence to the palm. It will be remembered that the flexor tendon sheaths of the thumb and little finger commonly extend into the palm and frequently communicate with the common sheath of the flexor tendons beneath the annular ligament of the wrist, and that, on the other hand, the tendon

sheaths of the second and third fingers ordinarily do not so communicate, and further that the fourth finger may or may not do so. Accordingly, infections of the thumb and little finger are more apt to be followed by palmar abscess and infection of the forearm than are those of the second, third, or fourth fingers. Nevertheless, in the last three the limits of the tendon sheaths form by no means an insurmountable barrier to the progress of the infection, nor can we count upon any such limitation in the given case. In another group of cases, not only will the tendon sheaths be invaded, but also the periosteum of a phalanx and the phalanx itself. In these, necrosis of one or several phalanges, most commonly the terminal one, is a not uncommon result. In another group of cases, already described when speaking of Pyogenic Infections in Vol. I, the local signs and symptoms remain slight, but there occurs a rapidly progressive lymphangitis of the hand, forearm, and arm evidenced by red and inflammed streaks visible upon the skin and extending often as far as the axilla. In these cases the constitutional symptoms of sepsis may be grave and even fatal. In others, they will not be so severe and the pus cocci will be stopped and retained in the axillary lymph nodes with the results described under Axillary Abscess.

The *signs and symptoms* of acute pyogenic infection of the pulp of a finger are fairly characteristic. Following some slight trauma, as the prick of a needle or some little abrasion upon the pulp of the terminal phalanx, the patient will observe a painful, tender point in the skin. There may or may not be an area of redness, but the finger is distinctly swollen and hot. The most characteristic symptom is the pain, the pus being confined among the fat lobules surrounded by dense connective tissue, is under high tension and presses upon the abundant sensitive nerve endings of the part. The pain is of an aching, throbbing character, usually sufficient to prevent sleep. The most characteristic local sign is *the presence of a point of extreme tenderness*, and in certain cases this sign by itself is a sufficient indication for incision. It cannot be too constantly borne in mind that this extreme localized tenderness on pressure is not only an indication for incision, but also points, without fail, to the most intense area of infection. The recognition of this fact is the more important since, as was pointed out when describing the Anatomy of the Fingers, the dense, connective tissues of their palmar surfaces do not permit of very marked swelling, nor can fluctuation be detected as a rule. The skin of the back of the hand, however, readily becomes swollen and edematous, so that an abscess situated upon the palmar surface may show all the signs of acute inflammation, much more marked upon the dorsum of the finger—namely, heat, redness, and swelling, while the focus of suppuration is situated in the pulp of the flexor side of the finger. It therefore happens that the inexperienced frequently make their cut in the wrong place. The cut should be made with the point of extreme tenderness as a center, and should be sufficiently liberal to pass through the entire thickness of the infected structures and to relieve all tension. On the other hand, care should be used not to cut too deeply, thus injuring the tendon sheath

and periosteum unnecessarily. A liberal incision of this kind, if made early, will often be followed by immediate subsidence of the threatening symptoms and the wound will speedily take on a healthy reparative action. If, on the other hand, the cut is made in the wrong place, or too small, the infection of other structures will not be prevented and subsequent incisions will have to be made at the expense of prolonged suffering on the part of the patient and of a greater destruction of tissue. Abscesses of the finger may, of course, present upon the side or upon the dorsum, but here again a point of extreme tenderness will be observed at the center of the focus. This preponderance of swelling and redness of the dorsum of the hand prevails also in abscesses of the palm, and here again, while the signs of acute inflammation are most marked on the back of the hand, the tenderness will be in front, and here the incision should be made. (See also Vol. I, page 77.)

Suppuration at the Matrix of the Nail—Paronychia, Panaritium.—Pyogenic infection of the fold of skin at the base of the nail possesses certain peculiarities. The infection follows some slight crack, abrasion, or puncture, usually just at the lateral border of the nail, where it disappears beneath the skin, although it may originate in other situations. The fold of skin at the side of and covering the nail becomes red, swollen, tender, and hot. In some cases a minute abscess will be formed at the side of the finger, containing a drop of pus. In others the process will spread, slowly or rapidly, across the finger at the base of the nail and after a short time a purulent discharge will appear between the nail and the overlying fold of skin. In some of the cases the disease tends to take on a subacute or even chronic character. From time to time a minute incision will be made and will evacuate a drop or two of pus, but as the infection travels along the base of the nail, the nail itself becomes separated from its matrix and constitutes a foreign body. Each movement of the finger or traumatism to the nail irritates the infected matrix. The condition gets better for a few days and then worse, until at the end of weeks, sometimes even months, the entire nail becomes loose and is removed as a foreign body, after which the infection usually gets well. The treatment of these cases is sometimes puzzling. In all, incisions should be made to provide for adequate drainage. The finger should be kept as far as may be elevated and surrounded by a wet antiseptic dressing. If it is evident that the infection is spreading and has finally involved the entire matrix, it is better to remove the nail entire. In other cases it will be sufficient to split the nail and remove such a portion of it as to free the inflamed part of the matrix from the presence of an irritating foreign body.

Palmar Abscess.—Abscesses of the palm may originate from the infection of a wound of the palm itself, or as an extension from pyogenic infection, usually of the flexor tendon sheaths of the fingers. The signs and symptoms resemble those of palmar abscess of the finger, but are more severe. Locally, there is intense throbbing pain in the palm with *extreme tenderness over the center of the lesion.* The constitutional symptoms are severe and are those of septic infection, as elsewhere described. Here, as in the fingers, the dense tissues of

the palm do not permit very extensive swelling, nor can fluctuation usually be detected. The back of the hand usually becomes swollen, red, and edematous, and these signs may mislead the inexperienced. If the condition is neglected the common tendon sheath of the flexors at the wrist is invaded and the intermuscular planes of the forearm become the seat of a suppurative process. The invasion of the forearm may occur early or late. In some cases the process is insidious, in others quite early in the disease the forearm becomes swollen, edematous, and tender. The tenderness, however, is by no means so marked as is the case with the palm of the hand. In some instances after a palmar abscess has been opened it will be observed that pressure upon the flexor surface of the forearm causes pus to exude from among the tendons from beneath the anterior annular ligament. This sign is an indication for incision of the forearm. My own experience is, that better results are obtained by one long incision which may or may not divide the annular ligament, according to the intensity of the infection and the stage at which it is first seen, than by numerous small incisions. By the former method, all tension and tendency to pocketing and retention of pus is removed, and the mechanical conditions are rendered most favorable for the tissues to overcome the spread of the pyogenic cocci. In making his incisions for abscesses of the fingers, the palm, and the forearm, the surgeon must be guided by his anatomical knowledge and avoid injuring or dividing unnecessarily, important structures. The palmar arches may usually thus be saved, and by making his cuts always in the long axis of the limb when making incisions above the wrist joint, he will avoid injuring important blood-vessels or nerves, though upon the radial side of the dorsum of the wrist care must be taken not to wound the tendons passing obliquely toward the thumb.

In the cases in which the bones of the phalanges or of the hand are involved and undergo necrosis, the presence of a sequestrum may be suspected from the formation and continuance of sinuses. The introduction of a probe will enable the surgeon to detect the presence of exposed bone. Such sinuses may also remain when the acute process has subsided and a sloughing tendon remains behind. Invasion and destruction of a joint is indicated by pain on motion, pain on crowding the joint surfaces together, and bony grating if the cartilages are eroded, when the affected joints are flexed. Such joint destruction is an indication for resection, or removal of the bones entering into the joint, sometimes for amputation of one or more fingers.

The suppurative processes of the fingers and hand are frequently accompanied by lymphangitis. Infection with *streptococci* is more apt to be followed by lymphangitis than with other forms. In these cases the constitutional symptoms often come on suddenly and are of great severity. The patient has a chill, high fever, prostration, and at once becomes very ill indeed. The red streaks, already elsewhere described, running up the arm are visible. The process may localize itself in the axillary lymph nodes with the production of abscess, or in other cases the infection becomes generalized and the patient goes on to die of septicemia. In some cases thrombophlebitis of the veins of the

forearm occurs with the production of pyemia. For the diagnosis of these processes the reader is referred to the sections on the Diseases of Wounds, Vol. I.

The fingers are less frequently frost-bitten than the toes, the ears, and the nose. The signs and symptoms of freezing of the fingers are the same as in other parts of the body—namely, after a slight frost-bite the finger becomes red, hot, swollen, tender, and painful, but without other lesion, except a tendency to recurrence of the pain, swelling, redness, etc., upon subsequent exposures to cold (chilblains, in other words). After more severe exposures, the formation of blebs upon the affected fingers may occur, or, in still more severe cases, actual gangrene of the whole or a portion of the finger. These conditions are readily recognized, and are fully described in Vol. I.

Burns of the Hand and Fingers.—Burns of the hand and fingers are frequent, sometimes as the result of exposure to steam, hot water, hot metal, or flame, and in other cases as the result of exposure to caustic liquids, acids, notably carbolic acid, and others. These injuries are readily recognized and

FIG. 167.—CARBOLIC ACID GANGRENE OF A FINGER. (New York Hospital, Out-Patient Department.)

present no difficulties in diagnosis. (See Burns and Gangrene, Vol. I.) Their importance lies chiefly in the fact that following the healing process cicatricial contraction may occur with the production of crippling deformities. These are readily recognized upon inspection.

Furuncles of the Hand and Fingers.—Furuncles of the hand and fingers occur only upon the dorsal surface. They are usually due to infection of the glandular structures of the skin. Typical furuncles of the hand and fingers possess no special characters different from furuncles in other situations, except

that here they are more likely to be followed by lymphangitis and constitutional infection. They are frequently multiple and occur especially among those individuals whose occupations expose them to contact with infected materials—surgeons and nurses, butchers, workers in hides and leather, cooks, cleaners of fish, etc.

Erysipeloid, Erythema Migrans; Rosenbach's Erysipeloid.—The favorite localization of this disease is upon the dorsum of the fingers and hand. (See page 143, Vol. I.)

Syphilitic Chancre of the Finger.—The primary lesion of syphilis is rather rarely located upon the hand or fingers, except among surgeons and obstetricians,

FIG. 168.—TUBERCULOSIS OF THE WRIST-JOINT AND OF THE METACARPAL BONES. Tuberculous ulcer upon the dorsum of the hand. (Service of Dr. Frank Hartley, New York Hospital.)

among whom it is lamentably frequent. It occurs in the vast majority of cases upon the terminal phalanx of the index finger. The chancre may be situated anywhere upon the finger, but the ordinary site is at the base of the nail. In the cases I have seen the lesions were rather large and showed a tendency to rather wide ulceration. Induration of the base of the ulcer is present, but, on account of the density of the surrounding structures, it is difficult to recognize. In many instances the diagnosis is not made at once. For a time it is usually regarded as an ordinary subacute pyogenic infection. The epitrochlear gland is the first to become enlarged; the axillary glands are next involved and may form considerable tumors. Constitutional symptoms follow in due course. As elsewhere related, I have seen chancre upon the knuckle as the result of striking a syphilitic individual in the mouth. The teeth produce the wound and the secretion from open lesions in the mouth furnish the infection. A photograph of a chancre of the finger which came under my observation is shown in Vol. I,

page 313. For the secondary and later lesions of the hand see page 323, Vol. I.

Tuberculosis of the Skin of the Hand.—Tuberculosis of the skin of the hand occurs in a variety of forms and usually upon the dorsum of the hand or fingers. It is characterized here, as elsewhere, by its very chronic course, by a tendency to persist and to return in spite of treatment, and by the fact that when it involves the dorsal surfaces of the fingers it produces disability and deformity by cicatricial contraction, such that the individual is no longer able to flex the fingers. After a time subluxation of the finger-joints may occur. The various typical forms of lupus are observed upon the hand, as well as verruca necrogenica (anatomical tubercle), and as a special form the so-called tuberculosis verrucosa cutis of Riehl and Paltauf. (See Vol. I.) The typical forms of lupus usually occur in individuals afflicted with other tuberculous lesions, and in these cases the general health and entire habitus of the individual will usually be modified in characteristic ways, easily recognized. The patients are children or young persons in the majority of instances. The so-called anatomical tubercle and the verrucous form, are inoculation diseases and may occur in persons otherwise quite healthy. The prognosis in this latter group of cases is much better. Excision of the affected areas and skin grafting is often followed by cure.

Tuberculosis of the lymphatic channels of the hand and forearm is occasionally observed, usually in combination with tuberculosis of the skin and of the axillary glands. The lymphatic channels become palpable as indurated cords beneath the skin, and in the latter stages of the disease multiple tuberculous abscesses may form involving the skin, with the characteristic appearances of tuberculosis and if allowed to rupture with the formation of tuberculous ulcers.

Syphilitic Dactylitis.—Syphilitic gummatous inflammation of the phalanges of the fingers may begin as a typical gummatous osteitis or periostitis, and may involve the soft parts of the finger as well. The disease is more often localized in the proximal phalanx of the index or middle fingers than elsewhere. A chronic, slowly progressive, fusiform enlargement of the finger is produced, usually almost entirely painless. In the end, softening, ulceration, and destruction of the phalanx may occur, but if promptly treated the lesions improve rapidly, as a rule. The disease is most often observed in children, and the syphilis is frequently of the hereditary type. If the skin and soft parts of the finger are early involved, there will be the characteristic raw-ham or copper-colored discoloration of the integument, and if ulceration occurs, the typical characters of gumma are readily recognized. One of the most characteristic features of the disease is its painlessness, unless ulceration occurs with secondary pyogenic infection.

Trophic Disturbances of the Hand and Fingers.—The trophic disturbances following injuries of nerves have been sufficiently described in Chapter VIII. In the course of diseases of the spinal cord, notably SYRINGOMYELIA, GLIOSIS

SPINALIS, ulcerations and mutilations of the fingers are not uncommon lesions. The lesions produced and the destructive effects closely resemble those of leprosy. Owing to the accompanying anesthesia, the ulcerations and slowly progressive gangrenous processes complicated by pyogenic infections are not painful, and these patients often go about without proper protective dressings, so that the affected fingers are continually subjected to mechanical and other insults. Ulcers form upon the terminal phalanges and progress slowly or rapidly, according to whether or not the finger becomes infected with pyogenic germs or is, on the other hand, carefully protected. The tendency is toward slowly progressive destruction of one or several fingers; one phalanx after another is lost, until the hand may be reduced to a stump, from which the remnants of the fingers project as more or less useless appendages. Usually the entire extremity becomes more or less atrophied, and inasmuch as the ulcerative lesions tend to assume a circular form surrounding the finger, the diagnosis in the presence of other symptoms of the disease is not difficult.

The development of softening, absorption of the nervous elements, and the formation of a cavity within the spinal cord with more or less extensive destruction of the nervous elements, is the characteristic lesion of the disease. The cavity lies usually in the posterior portions of the cord, near the central canal, and may extend for a long distance up and down the cord, so that the major portion of the nervous elements is destroyed.

There are three characteristic groups of symptoms. There is loss of the sensation of pain and of the temperature sense, in different portions of the body, with preservation of ordinary tactile sensibility. There is progressive atrophy of the muscles attended by paralysis, and there are trophic disturbances in the skin, in the muscles, in the bones, and in the joints.

Symptomatology.—The localization of the lesions in the hand causes several groups of peculiar symptoms. In 1883 a disease was described by Morvan which he observed among the fishermen in France. There were abscesses followed by deep ulcerations and necroses of the phalanges of the fingers, associated with other trophic disturbances in the skin and with loss of pain sense. The autopsies showed cavities in the spinal cords of these individuals. Therefore the peculiar lesions observed in the hands of persons afflicted with syringomyelia is sometimes known as Morvan's disease. Partly as the result of trophic disturbances and partly because these patients do not feel pain, they frequently injure and mutilate their fingers, and such injuries are followed by infection. As a consequence, suppurative and gangrenous processes occur with more or less complete destruction of the fingers. In addition there are destructive lesions of the joints closely resembling those observed in locomotor ataxia with this distinction, that in syringomyelia the joints of the upper extremity are commonly affected, while in lomomotor ataxia the lower extremity is more often involved. There is in addition atrophy of the muscles of the hand, forearm, and arm. The atrophy usually begins in the small muscles of the hand (first, lumbricalis is usually earliest involved),

and gradually extends upward. The thenar and hypothenar eminences lose their prominence and become flat. As the result of the atrophy and paralysis of the muscles of the forearm, the hand assumes the position of the *main en griffe*. Destruction of the finger-joints, the wrist-joint, the elbow-joint, and the shoulder may occur. The degree of mutilation of the hand varies in different cases, according to the presence or absence of accidental infections, burns, and other injuries. The presence of the characteristic symptoms as described renders the diagnosis simple in most cases. The prognosis is unfavorable though the disease is not always progressive beyond a certain point, so that life may be prolonged for many years.

Presenile Gangrene, Intermittent Claudication, Raynaud's Disease, and Localized Arteriosclerosis.—These conditions are much less frequently observed in the fingers than in the toes. The symptoms of these conditions have been briefly described in Vol. I. (See also Vol. III, Diseases of the Foot, Chapter XXX.)

Diabetic gangrene and necrotic processes of the hand and fingers caused by pyogenic infections are quite common in the course of saccharine diabetes. As described in Vol. I, they are characterized by constitutional depression, by the presence of large quantities of sugar in the urine, and locally by a tendency to progress uninfluenced by treatment, by an almost entire absence of reparative effort on the part of the affected tissues, and by the absence of the signs of ordinary acute pyogenic infection, due to this want of reaction. The ulceration, necrosis, or gangrene may begin in the pulp of the fingers or upon the back of the hand and may progress slowly or rapidly, the spread of the disease into the deeper tissues of the hand being often insidious. (See Diabetic Gangrene, Vol. I.) Gangrene of the fingers as the result of the application of caustics is most commonly produced by carbolic acid. (See Carbolic Acid Gangrene, Vol. I.)

Ganglion of the Wrist.—Cystic tumors containing usually gelatinous (colloid) fluid, varying in size from that of an almond to a pigeon's egg, seldom very much larger, are observed frequently upon the dorsum of the wrist, although they may appear in other situations. At the present time these cystic formations are believed to be due, at least in a large proportion of cases, not to a hernia of the synovial lining of a joint, nor yet to a localized cystic formation in the tendon sheaths, but to a form of connective-tissue degeneration called colloid, usually in connection with a tendon, sometimes developed within the tendon itself. Whatever the origin of the condition, the diagnosis is readily made. The ganglion forms an elevated, rounded, tense, and elastic nodule, most commonly upon the dorsum of the wrist, near the radial side and opposite to the wrist-joint. Usually these patients do not suffer pain, but from a notable weakness in making certain motions of the wrist and fingers. If the tumor is examined in its early stages, it may feel quite hard. Later on, when a considerable cyst cavity is formed, fluctuation may be detected. If the tumor is attached to a tendon merely, it may be moved from side to side, but usually

attachment to the deeper structures render the mass quite immovable. It is sometimes impossible to differentiate ganglion from the more chronic forms of tuberculous tenosynovitis with a fluid or gelatinous exudate. The latter, however, produce a greater disturbance of function and the lesions are usually multiple. (See Tuberculosis of the Tendon Sheaths.) The treatment of ganglion is a careful removal of the sac by dissecting it out with a knife.

FIG. 169.—GANGLION ON THE BACK OF THE WRIST. (Drawing by Dr. B. S. Barringer.)

DISEASES OF THE BONES AND JOINTS OF THE WRIST AND HAND

Tuberculosis of the Wrist-joint.—Tuberculosis of the wrist-joint is observed in young adults and during the active decades of life, more often than in children. It is a localization of the disease usually accompanied by serious tuberculous lesions in other parts of the body. Frequently it is associated with tuberculosis of the lungs and in other cases with tuberculosis of other joints, or of other bones. The lesion is usually primary in the lower end of the radius and secondarily involves the joint. The process may remain as a localized tuberculous osteitis in the lower end of the radius for a long period before the joint is invaded, and in these cases, if seen early, there may be a good opportunity to eradicate the disease by operating upon the radius before the wrist-joint is involved. The tuberculous process in the radius may make known

FIG. 170.—TUBERCULOSIS OF THE WRIST-JOINT. (New York Hospital collection, service of Dr. L. A. Stimson.)

its presence by moderate pain and tenderness with slight enlargement of the bone, the last indicating a tuberculous periostitis. In a few cases perforation takes place at first, not into the joint cavity, but among the tendons, with the production of a tuberculous tenosynovitis, though the last is much more commonly due

FIG. 171.—TUBERCULOSIS OF THE WRIST-JOINT. (New York Hospital, Out-Patient Department.)

to the perforation of the tuberculous process in the wrist itself with secondary invasion of the tendon sheaths. When the wrist-joint itself is involved the ordinary changes are produced, commonly observed in tuberculosis of the other joints. There is at first limitation of motion at the wrist followed by complete loss of function and stiffness, the muscles of the forearm undergo a characteristic atrophy, and the spindle-shaped enlargement of the wrist is fairly characteristic.

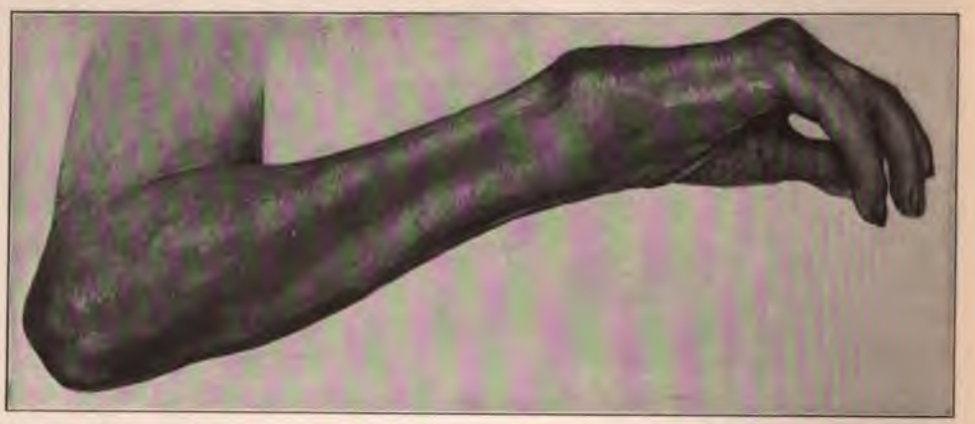

FIG. 172.—TUBERCULOSIS OF THE WRIST-JOINT, SHOWING FLEXION OF THE FINGERS WHICH COULD NOT BE FURTHER EXTENDED. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

Secondary involvement of the tendon sheaths leads to swelling of the soft parts, with a more or less firm and elastic or doughy swelling. The diminution of function and mobility of the tendons and consequently of the fingers is steadily progressive, so that in the advanced stages the wrist and the fingers may be in

a state of extension and almost immovable. The formation of a tuberculous abscess and of sinuses is common in the later stages. Such sinuses usually form upon the radial side and dorsum of the wrist. The presence of other tuberculous lesions, together with the chronic course, aids greatly in the diagnosis.

Tuberculosis of the Bones and Joints of the Hand and Fingers.—In the phalanges of the fingers there occurs the most typical of the tuberculous lesions, elsewhere spoken of in Vol. I as "spina ventosa." The localization is almost peculiar to children and persons who have not yet reached adult life. The lesion consists of a tuberculous osteomyelitis of one or more phalanges with the production of a periostitis and a typical spindle-shaped enlargement of the bone and of the finger. The disease is practically painless, and in the early stages the function of the finger may be partly preserved. Later, when the swelling has become more marked, the finger will become stiff, usually in the extended position. In the advanced stages one may discover crackling of the thin shell of bone on palpation, or in more advanced cases still, with marked bony destruction, there may be fluctuation and the production of a tuberculous abscess, which ruptures, leaving behind a tuberculous sinus leading to softened tuberculous bone. The only disease with which tuberculosis of the bones of the fingers is likely to be confounded is tertiary syphilis in the hereditary form. Other syphilitic manifestations will usually be present. Secondary tuberculous invasion of the joints may occur, and such may involve the metacarpo-phalangeal joints, or the joints between the phalanges. The diagnosis of invasion of the joints is to be made by the inclusion of the joint in the swelling, by the presence of bony grating and of pain, when the eroded joint surfaces are crowded together. Invasion of the ligamentous structures entering into the joint is followed by abnormal mobility of the finger laterally and in some cases by subluxation.

FIG. 173.—TUBERCULOSIS OF THE FIRST PHALANX OF THE FOURTH FINGER WITH TUBERCULOUS ULCERATION OF THE SKIN AND ENLARGEMENT OF THE BONE. (Case of Dr. Charles N. Dowd.)

Trigger Finger, Snapping Finger.—In this condition the motions of flexion and extension, one or both, in one of the finger-joints exhibits the peculiarity that when the patient attempts to make a certain motion, it proceeds to a given extent and then stops. In order to continue the movement a powerful muscular

contraction must be made, when the obstruction suddenly gives way with a snap and the motion is completed. In some cases the motions of flexion and extension may be made to the physiological degree, in others they may be more or less limited. The condition may occur in any of the fingers, but is most frequent in the middle finger, in the fourth finger, in the thumb, and index finger, in the order named. The condition may arise spontaneously. In other cases it has followed injury, or may occur as one of the symptoms of arthritis deformans. Upon dissection, localized fibrous thickening of the tendon has been observed in certain cases, so that at a certain point in the excursion the enlarged portion of the tendon is caught and held by its sheath. From the description, the diagnosis needs no further comment.

Acute Purulent Inflammations of the Joints of the Wrist and Hand.—Acute purulent inflammations of the wrist-joint and of the joints of the hand and fingers need no special diagnostic description. Here, as elsewhere, they may follow a great variety of causes, local and general, of an infectious nature, due to open wounds or to the localization of septic or other specific infectious processes in the affected joints. Among such may be mentioned gonorrhea, typhoid fever, pyemia, acute osteomyelitis of the bones of the forearm and hand, pneumonia, and other conditions which will be found described under Diseases of the Joints of the Upper Extremity, Chapter VIII. Here, as elsewhere, these inflammations are characterized by loss of function in the affected joint, by pain, by swelling, by constitutional symptoms of sepsis, and in severe cases by destruction of the bones and soft parts entering into the joint, etc., as described under Purulent Inflammation of Joints, Vol. I. In cases of doubt, the character of the exudate in the joint is readily determined by the use of the aspirating syringe and culture experiments.

TUMORS OF THE WRIST AND HAND

Benign Tumors of the Wrist and Hand.—A great variety of benign tumors have been observed upon the wrist and hand. Hard papillomata are particularly frequent upon the hand and fingers. They are much more frequent in childhood than at any other period, and are believed to be due to mechanical injury or irritation. They are said to be inoculable upon the same individual. They usually remain small, though in rare cases certain so-called "seed warts" may reach the size of a large buckshot, or even larger. They are often tender, and are frequently wounded or cracked near their bases by slight mechanical violence. They are readily removed by caustics or by excision.

The Tumors of the Blood-vessels Affecting the Forearm and Hand.—The most important of these, cirsoid aneurism or aneurism by anastomosis, has received attention elsewhere. The ordinary forms of angiomata, nevus, and occasionally cavernous angioma, are observed as small and usually circumscribed tumors in the skin of the wrist and hand. For their diagnosis see Tumors, Vol. I.

Lipoma.—Lipomata are rare tumors upon the wrist and hand. They have, however, been observed as small circumscribed and as diffuse subcutaneous growths. The diagnosis of the circumscribed forms when they occur in the ordinary situation of ganglion may offer some difficulties. Lipomata have been described occurring on or beneath the flexor tendons of the palm, in the vicinity of the annular ligament. Hence they tend to spread downward and may grow in the interspaces between the metacarpal bones and appear upon the back of the hand. The diagnosis could best be made by incision, since the growth would so closely resemble a productive tuberculous inflammation of the tendon sheaths that an error of diagnosis would be probable. It is, however, to be borne in mind that tuberculous inflammations of the tendon sheaths of the palm spread upward beneath the annular ligament to the forearm, while lipoma tends to grow downward toward the fingers.

Fibroma.—Fibroma is a tumor rarely found arising from the skin and subcutaneous tissues of the hand. The diagnosis is not difficult. The tumors present the ordinary characters of fibroma, either hard or soft, and are movable upon the tissues beneath. (See Fibroma, Vol. I.) *Keloid* sometimes develops in the scars following wounds with loss of substance, infected wounds, and burns of the hand and fingers. They more commonly develop upon the dorsum than upon the palmar surface of the hand.

Fibromata of the deeper structures of the palm may develop in the palmar fascia, or in the tendons. They usually follow trauma and exist rather as masses of cicatricial tissue than as true new growths. When a small fibroma of this kind develops in a flexor tendon of a finger it may produce the condition described in a preceding paragraph known as "snapping finger."

The so-called *epithelial implantation cysts* are occasionally observed upon the hand. They follow an injury, either an incised or a contused and lacerated wound, such that a portion of skin is mechanically displaced into the subcutaneous tissues and there produces a cystlike tumor, usually of small size and firm or elastic consistence, containing the elements of the secretions and organized structures of the skin. The affection is one almost peculiar to men. The index finger is the favorite site of the tumor, though such may occur in the palm or in other parts of the hand. A tumor probably of this character upon which I operated many years ago in the Roosevelt Hospital is shown on page 265, Vol. I. In this case the tumor was plainly of a cystic character. In some of the recorded cases the cyst has been thick-walled and of firm consistence, resembling a solid growth. In others a foreign body has been found in the center of the cyst. An accurate diagnosis of the character of these cysts can best be made by microscopic examination of the cyst contents and of sections of the cyst wall.

Neurofibromata.—Neurofibromata of the hand and fingers follow traumatisms. They form usually spindle-shaped enlargements of the nerve trunks, and may give rise to disturbances of sensation in the fingers and be followed by a neuritis. The situation of the tumor can be determined from the site of the injury and from localized tenderness on pressure.

Enchondroma.—Cartilaginous tumors, often multiple, occur in the bones of the hand and fingers more often than elsewhere. They may remain of small size, or in other cases grow quite large and produce ugly deformities with marked loss of function. In a certain proportion of these cases the tumors remain benign, in others they undergo sarcomatous or myxomatous degeneration, produce metastases and exhibit all the characters of malignant new growths. The diagnosis of enchondromata of the hand and fingers is easy. They occur in young persons, or have originated in youth. They are hard nodules, firmly attached to the bone, and so long as they are not in combination with osteoma, are very permeable to the X-rays. The osteomata of the hand and finger bones are much rarer tumors. They have a broad attachment to the bone, are very hard, and their bony structure is readily demonstrated by an X-ray picture.

Malignant Tumors of the Hand and Fingers.—The malignant tumors of the hand and fingers are SARCOMATA and EPITHELIOMATA.

Sarcoma.—The sarcomata may originate in warts, pigmented moles, and nevi of the skin of the hand. Numerous forms of sarcoma have been observed in the *skin* of the hand, but the spindle-celled sarcomata and melano-sarcomata are the most frequent forms. The former may grow slowly for a long time, suddenly to take on a more malignant character, whereas the melano-sarcomata originating in pigmented moles, when once started, are disseminated throughout the body with frightful rapidity. The sarcomata of the *bones* have here more

FIG. 174.—SARCOMA OF THE WRIST. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

commonly a central origin and may be of various types and of varying degrees of malignacy. Before they have perforated into the surrounding soft parts they may produce a spindle-shaped enlargement of the bone, a spinosa ventosa. The periosteum once perforated, the soft parts are rapidly invaded, other bones are infiltrated and destroyed, and large tumors may be produced showing the ordinary characters of sarcomata. Giant-celled sarcoma originating in the periosteum is less common, and here rather less malignant as a rule than other types. Combinations of sarcoma with fibroma of varying degrees of malignancy may originate in the soft structures of the hand, notably in the tendon sheaths, and in the nerve trunks. Sarcomata of the nerve trunks have been described in a preceding chapter.

Epithelioma.—Epithelioma occurs with only moderate frequency upon the hand and fingers. Most often upon the dorsum, rarely upon the palm. Such epithelomata may occasionally originate in congenital warts, rarely, it is believed, in papillomata which develop later in life. Much more commonly epitheliomata arise upon the sites of former scars, or upon surfaces the seat of chronic mechanical or chemical irritation. During the past ten years numerous

FIG. 175.—EPITHELIOMA OF THE THUMB. (New York Hospital collection.)

valuable lives have been sacrificed as the result of repeated exposures of the hands to the X-rays by surgeons and other X-rays workers. The chronic inflammation of the skin and the trophic changes produced by repeated exposures to the rays eventuate in keratoses, and these in shallow ulcerations which refuse to heal, and after existing for months or years take on the characters of typical epithelioma. Glandular infection follows, and in spite of extensive and mutilating operations the individual is doomed.

CHAPTER XVII

INJURIES OF THE HIP

ANATOMICAL REMARKS

(Partly adapted from Merkel, Woolsey, and A. Hoffa.)

THE bony structures entering into the hip-joint are the acetabulum, or cotyloid cavity of the os innominatum, and the head of the femur. The acetabulum forms a hemispherical hollow surface into which the head of the femur fits. The border of the acetabulum is surrounded and covered by a strong, firm ring of fibro-cartilage, with a sharp border called the *labrum glenoidale* or cotyloid ligament. This border so closely embraces the head of the femur beyond its greatest diameter that it holds the bone, and even the entire weight of the limb, in position by atmospheric pressure. This ligament also bridges over the depression in the margin of the acetabulum where the pubis, ilium, and ischium come together. During the growth of the pelvis, and before the three bones have united, the cartilages come together at the bottom of the cotyloid cavity in the shape of an inverted Y. This union occurs at about the eighteenth year. The bottom and lower portions of the acetabulum are thin. Above, as well as in front, and behind, the bone is very thick and strong to support the weight of the body. The articular surface of the acetabulum—i. e., that portion covered by cartilage—is about one half inch in width and of a horse-shoe shape, being incomplete below and to the inner side. The bottom of the cotyloid cavity is not covered with cartilage but is lined with synovial membrane merely, outside of which there is a sort of packing of loose fat. Although the bottom of the cavity is thin it rarely happens except from very great violence that it is injured by force transmitted through the head of the femur, the shapes of the head and of the cavity, respectively, being such that the head is prevented from bearing upon it. In disease of the hip-joint, however, during the earlier years of life, infection and destruction of the Y shaped cartilage may occur, so that the bones may be separated or the interior of the pelvis invaded by tuberculosis or by pyogenic germs. The acetabulum measures about 5 cm. in width at its rim, and from 30 to 35 mm. in depth in the male, shallower in the female.

The head of the femur is hemispherical in shape, or nearly so, since the sphere is slightly flattened. The radius of the sphere is about an inch. Rather more than half of that portion of the head covered by cartilage lies in front and above, rather less than half posteriorly and below. Just below the middle

of the surface, directed toward the acetabulum, there is a slight depression in the head for the attachment of the *ligamentum teres*, which passes from its attachment to the os innominatum upward and inward to the head of the femur. This ligament is put upon the stretch by adduction and outward rotation of the thigh. It is ruptured in complete traumatic dislocations of the hip-joint.

The head is joined to the shaft by the neck. The junction of the neck with the shaft is indicated by a line upon the bone which passes from the trochanter major to the trochanter minor (intertrochanteric line). The neck makes an angle with the shaft, which is in adults on the average about 130°, though it varies within certain limits. According to the researches of Rodet, quoted by Stimson, it is in the child and adult on the average 131°, in the aged 120°, though it may vary within normal limits between 121° and 144°. Charpys, quoted by Merkel, places the limits between 115° and 140°. The neck passes upward and a little backward to join the head. The center of the head of the femur lies about two inches vertically below the anterior inferior spine of the ilium. If, from the middle of a line joining the anterior superior spine of the ilium and the spine of the pubis, a second line be drawn downward and outward at right angles to the first, it will bisect the hip-joint into equal halves, and the middle of the head of the femur will be upon the second line distant from the first about two inches. For the time of appearance of the several epiphyses of the upper end of the femur, see section on the Epiphyses in this volume. For the bony structure of the upper portion of the femur, see Fractures of the Neck of the Femur.

The Capsule and Ligaments of the Hip-joint.—The capsule of the hip-joint is attached to the entire circumference of the cotyloid cavity, just beyond the sharp free border of the cartilage, whence it passes downward and outward to be attached at or near the junction of the neck with the shaft. The limit of attachment in front is the intertrochanteric line. Posteriorly, the capsule is attached to the neck itself, a short distance from the junction of the neck with the shaft. Thus posteriorly a small portion of the neck lies outside the capsule of the joint. Above, it passes to the digital fossa at the base of the great trochanter, and below to the upper limit of the trochanter minor. The capsular ligament consists of longitudinal and circular fibers which vary much in thickness and in strength on different aspects of the joint. As a whole, these ligamentous structures are the strongest in the body. The weakest portion lies posteriorly and below where the synovial membrane of the joint is reflected upon the neck of the femur. Details will be found in succeeding paragraphs.

Over certain areas the longitudinal fibers are greatly increased in thickness and in strength. They constitute what are known as the *accessory ligaments*. Three of these exist. They are the *ilio-femoral ligament*, the *pubo-femoral ligament*, and the *ischio-femoral ligament*. Of these, the ilio-femoral ligament of Bertin, or as it was called by Bigelow, who demonstrated its importance in relation to dislocations of the hip-joint, *the* Y *ligament*, is much the strongest

and most important. It passes from the anterior inferior spine of the ilium and from the surface of bone behind and below it, downward, and a portion of it outward to be attached respectively to the lower and to the upper portions of the intertrochanteric line. The ligament divides into two bands at a variable distance below the inferior spine of the ilium, thus forming the limbs of the Y. As stated, the inner limb passes almost vertically downward to be attached to the lower part of the intertrochanteric line. The outer passes downward and outward to be attached to the upper part of the same. This ligament is the strongest in the body. It is about one quarter of an inch thick in its thickest part, and is capable, according to the experiments of Bigelow, of withstanding a strain of from 250 to 700 pounds.

In relation to dislocations of the hip, this ligament is of great interest and importance, since, except as the result of very great violence, it is not broken in dislocations of the hip-joint. It remains in most cases intact, and determines the movements of the head of the bone after it has left the glenoid cavity, and consequently the position of the limb, while the relations of the head and neck of the bone to the ligament in different dislocations determine the manipulations necessary for reduction. The inner portion of the ligament limits extension of the thigh, its outer limb limits external rotation.

The *pubo-femoral* ligament arises from the anterior and lower part of the edge of the acetabulum and pubic bone, as far inward as the pectineal eminence. It passes outward and downward to be attached just above the lesser trochanter. This ligament limits the motion of abduction.

The *ischio-femoral ligament* arises from the ischium below the acetabulum, and passes outward upon the posterior aspect of the joint to be attached to the femur. This ligament limits internal rotation of the thigh. Above and below the pubo-femoral ligament the capsule of the joint is thin and weak. In front, the thinnest portion is just below and external to the ilio-pubic eminence. At a point between the ilio-femoral and pubo-femoral bands this portion of the capsule has upon it a bursa separating it from the ilio-psoas tendon and muscle. The presence of this bursa is sometimes interesting from a pathological point of view, since a purulent exudate in the joint may extend to the bursa, or, on the other hand, a psoas abscess may invade the hip-joint. In later years the bursa and the joint may communicate. According to Heineke, this bursa communicates with the hip-joint in ten per cent of the cases by a large or smaller circular opening. A second weak place in the capsule, according to König, is immediately above the trochanter minor at the place where the tendon of the obturator externus muscle is in relation with the tendon of the ilio-psoas. The thin and weak portion of the capsule posteriorly lies internal to the pubo-femoral ligament, and rupture of the capsule occurs more often in this situation than in any other.

The motions of the hip-joint are extremely varied; much the most important of these are the motions of flexion and extension, which give the lower extremity that pendulum action necessary for walking. In these motions also the head

of the bone is most secure in the cotyloid cavity. The motion of extension is, as stated, limited by the tension of the ilio-femoral ligament. Flexion is limited by the contact of the front of the thigh with the soft structures of the groin and the abdominal wall, when the knee is in the state of flexion. When the knee is extended, flexion of the thigh at the hip-joint is limited by the tension of the powerful flexor muscles of the knee (the ham-string muscles). Abduction is limited by the pubo-femoral ligament; adduction by the outer portion of the ilio-femoral ligament; external rotation by the ilio-femoral ligament, its outer part during flexion and its inner part during extension; inward rotation by the ischio-femoral ligament during flexion, by the ilio-femoral ligament during extension.

In relation to the diagnosis of dislocations of the hip-joint, NÉLATON'S, or the ISCHIO-ILIAC line, is of very great importance. The line is drawn from the anterior superior spine of the ilium outward and backward across the outer surface of the thigh to the lowermost portion of the tuberosity of the ischium. In a normally developed hip, when the thigh is slightly flexed, this line crosses the upper part of the great trochanter. The most superficial portion of the great trochanter, which is readily palpable, lies about an inch below the top of this process, since the trochanter curves inward at its upper part and overhangs the neck of the femur. The changed relations of the top of the trochanter to Nélaton's line are of the greatest importance in the diagnosis of dislocations of the hip-joint, as will be described under Dislocations of the Hip. The hip-joint is so surrounded by heavy muscles and other soft parts that it is not directly open to examination by palpation. It is not necessary to enumerate the muscles in relation to the hip-joint, but the most important of them, in its relation to dislocations of the femur, is the obturator internus. This muscle arises from the inner surface of the obturator foramen and the surface of bone lying between it and the great sacro-sciatic notch and passes outward through the lesser sacro-sciatic notch, where it turns sharply forward, as on a pulley, and is inserted into the inner surface of the great trochanter near its anterior border. Above the obturator internus is the pyriformis muscle. Below it the quadratus femoris. In dorsal dislocations of the hip the head of the bone may leave the joint and pass either below or above the tendon of the obturator internus, or the muscle may be more or less extensively ruptured. For further details see Traumatic Dislocations of the Hip.

CONGENITAL DISLOCATION OF THE HIP

Though congenital dislocation of the hip is rather a rare condition, it is relatively frequent in that congenital dislocations are more often observed in this joint than any other. It is much more frequent in females than in males, and is not rarely double.

Causation.—The causation of congenital dislocation of the hip is unknown. It is not infrequently associated with other deformities, and may be regarded

as to some extent hereditary, since several examples are sometimes found in the same family.

Pathology.—The acetabulum is always present and in its normal position, but is shallower than normal and sometimes triangular in shape. It is believed that during the earliest stages of development the head of the femur and the acetabulum are in their normal relations, but as the head of the femur grows larger, it is unable to rest in the small and shallow acetabulum, and it is gradually drawn upward and backward by the action of the attached muscles, so that the head comes to lie behind and above the cotyloid cavity. In most instances the dislocation is of the backward variety, and the head of the bone becomes somewhat flattened where it rests against the pelvis. The ligamentum teres is usually present and is lengthened, and is drawn out into a flat band. No notable deformity is observed until the child begins to walk, when the head of the bone undergoes a further upward displacement, where it is supported by the stretched ligaments and by the surrounding muscles, and at a later period by the formation, in some cases, of a false joint upon the surface upon the ilium. The neck of the femur is rotated so that it points farther forward than normal. In other cases the head of the bone does not rest against the ilium, but is suspended merely by the muscles and ligaments. The joint capsule is stretched across the acetabulum, to which it becomes more or less adherent. The cavity of the capsule also becomes narrower and may be so constricted that it is too small for the passage of the head, and thus forms one of the obstacles to reduction. As time goes on, deformity of the pelvis is developed. In the unilateral cases a marked deformity of the pelvis occurs on account of the abnormal point of support, such that the crest of the ilium is displaced inward while the ischium is displaced outward, as though the innominate bone were rotated upon an antero-posterior axis. The pelvis is also rotated, or rather changed in shape, in such a manner that its center lies farther upward and backward than normal. The horizontal ramus of the pubis is increased in length and is directed upward and backward to an abnormal degree. In bilateral cases a similar deformity occurs upon both sides, so that the entire pelvis is tilted forward and the crests of the ilia are nearer together than normal—that is to say, the entire pelvis is compressed laterally as well as tilted. The condition frequently remains unrecognized until the

FIG. 176.—CONGENITAL DISLOCATION OF THE HIP IN A LITTLE GIRL AGED TEN. (New York Hospital collection.)

child begins to walk. In the bilateral cases the ability to walk is delayed, and these children have a peculiar waddling gait, which is characteristic. There is marked lordosis. In the unilateral cases there is a well-marked limp. Partly on account of the lordosis, the buttocks are unduly prominent, and the trochanter projects to an abnormal degree. The perineum is broadened, and when viewed from the side, as the child stands, the prominence of the buttocks posteriorly and the marked lordosis are almost sufficient for a diagnosis, without other examination. In the unilateral cases there is shortening upon the dislocated side and a compensatory scoliosis in order to enable the patient to stand erect. As already stated, the entire pelvis is tilted forward. In the unilateral cases the muscles of the affected side are usually less well

FIG. 177.—UNILATERAL CONGENITAL DISLOCATION OF THE FEMUR. (X-ray by the author.)

developed. Upon palpation all the motions of the joint are found very free, except in some cases, abduction. Upon grasping the thigh with one hand and palpating the hip with the other, the upper end of the bone may be made to move up and down, and sometimes the head can be recognized on rotation. When the dislocation is bilateral, the scoliosis will be absent. In some of these

cases there is no pain. In others, as time goes on, the deformity and disability increase and pain may be complained of. In some cases the bone may be pulled down readily enough by the rim of the acetabulum and may be felt to slip over it with a jump. The dislocation may occur in one of three directions—namely, backward, upward, and forward. The first form is by far the most frequent. Measurements will show that the head of the bone is above Nélaton's line.

FIG. 178.—DOUBLE CONGENITAL DISLOCATION OF THE HIP-JOINT. (Author's collection.)

The diagnosis, not only as to the presence of the dislocation, but also as to the size and shape of the acetabulum, the length of the neck of the femur, and the shape and size of the head, can be made with great accuracy by means of stereoscopic X-ray pictures.

TRAUMATIC DISLOCATIONS OF THE HIP

Dislocation of the hip is a comparatively rare injury, and constitutes in the statistics of writers rather less than two per cent of all dislocations. The injury is more common in males than in females. It has been observed at all ages of life, from six months to extreme old age, but is most common during the early decades when the greatest activity exists. About half the cases occur before the age of twenty years (Prahl). The cases may be grouped broadly under two hands—namely, backward dislocations and forward dislocations, the backward group including the vast majority of all dislocations of the hip, the others being relatively rare. Dislocations of the hip may be simple or compound. Owing to the very large mass of soft parts surrounding the hip-joint upon all sides, *compound dislocations* occur only from very great degrees of violence. The injury itself, being a very dangerous one and often associated with other serious lesions, is fatal in a large proportion of cases. In this connection, Stimson says of the statistics of certain reported cases collected by him:[1] "The gravity of the condition, seven deaths in nine cases, is largely due

[1] L. A. Stimson, *loc. cit.*, p. 724.

to associated injuries and shock, five deaths; in the remaining four, the wound suppurated, after reduction, and two of them died. The urgent question is whether or not to excise the head of the femur in order to diminish the danger if suppuration should follow. In fresh, uninfected cases, I should think it unnecessary if ample drainage were provided."

Without going into the elaborate and somewhat confusing classifications which from time to time have been made of dislocations of the hip, and which are of more historical than of surgical interest, the author here quotes the

FIG. 179.—CONGENITAL DISLOCATION OF THE HIP; GIRL AGED THIRTEEN.
(Case of Dr. Wm. A. Downes, New York Hospital, Out-Patient Department.)

classification used by Dr. Stimson, with the remark that other than the dorsal dislocations the varieties mentioned are extremely rare, second in frequency being the obturator or thyroid dislocations—that is, downward and inward dislocations.

DISLOCATION BACKWARD.	Dorsal, comprising the "iliac" and "ischiatic" or those "upon the dorsum ilii" and "into the ischiatic notch" of the writers. Everted dorsal, comprising the anterior oblique, "supraspinous," and some of the "supracotyloid."
DISLOCATIONS DOWNWARD AND INWARD.	Obturator. Perineal.

Dislocations Forward and Upward.	Suprapubic	Ilio-pectineal. Pubic. Intrapelvic.
Dislocations Directly Upward.	(Supracotyloid or Subspinous.)	

Dislocations Downward on the Tuberosity of the Ischium.

Dorsal Dislocations.—Dorsal dislocation of the hip is, as stated, much th most common form. It occurs when the thigh is flexed, adducted, and rotate inward. When in this position, the head of the femur rests against and puts upon the stretch the posterior and inferior part of the capsule, which, as already stated, is its weakest point. Then, suitable violence being applied—such that one or other of the motions, flexion or rotation inward, or adduction, is increased—dislocation occurs. As, for example, when a patient falls from a height and strikes the ground with the thigh in the above position, or as when he stands with the thighs flexed and his body bent forward and some heavy object strikes him on the back. As a consequence the capsule gives way, it is torn, and the head escapes from cotyloid cavity; usually the ligamentum teres is torn from the femur or may be ruptured. The head of the bone passes backward over the rim of the acetabulum at a higher or lower point, and comes to rest usually with the limb in or near the position in which it was when dislocated. The head may rest behind and above or behind and below the acetabulum. In the former group are included the so-called dislocations upon the dorsum of the ilium; in the latter group, the ischiatic. It is believed that in a large number of cases posterior dislocations have been diagnosticated as upon the dorsum, whereas really the head of the bone was lower down upon the ischium. Be that as it may, in many instances a secondary displacement takes place, such that the head of the bone rises from its position upon the ischium to a point above upon the ilium. The rim of the acetabulum or its cartilage may be fractured, and the neighboring muscles are more or less extensively lacerated. The obturator internus may be but slightly torn, the head of the bone passing either above or below its tendon; or in other cases the muscle may be ruptured. The quadratus femoris is usually more or less lacerated. The pyriformis, the gemelli, and the obturator externus may be more or less extensively ruptured. The head of the bone may, as already stated, pass either below or above the tendon of the obturator internus, or the muscle may be stretched across the head without being ruptured. When the head passes through the lowest part of the capsule and beneath the tendon, it may subsequently pass upward as a secondary displacement behind the obturator internus. In this case, therefore, the primary displacement is downward and the secondary displacement upward, the latter being limited in extent by the remaining untorn portions of the capsule, and especially by the ilio-femoral ligament, which in reality determines and limits this secondary displacement, the attachment of the ligament to the femur forming the fulcrum of the lever, or a new center of motion, so that if the thigh

partly extended while the limb is still adducted and rotated inward, the head of the bone passes upward behind the acetabulum upon the dorsum of the ilium. If, however, extension of the thigh takes place and is accompanied by abduction or outward rotation, the head of the bone will pass in the opposite direction—namely, inward and forward—producing an obturator dislocation. The point where the head of the bone comes to rest in the ordinary types of backward dislocation may be as follows: Just behind and above the acetabulum, so that the center of the head of the bone lies on a level with the spine of the ischium constituting the ischiatic form, or in the typical dislocations upon the dorsum of the ilium, the head of the bone comes to rest in front of, but rarely above, the apex of the great sciatic notch.[1] It may be borne in mind that when the individual lies flat upon his back the great sciatic notch lies vertically below the anterior superior spine of the ilium. Associated injuries of the vessels and nerves are rarely present in dorsal dislocations.

The Symptoms and Diagnosis.—There is complete loss of function of the injured extremity. The thigh is flexed, adducted, and inverted. The limb appears shortened, the toes rest upon the dorsum of the other foot. This position is quite evident upon inspection if the patient stands erect upon the sound limb. If he lies upon his back the deformity becomes still more marked, so that the knee of the injured side may rest upon the opposite patella, or the injured thigh may cross the other even as high as its middle. The position of adduction, flexion, and internal rotation may be increased passively with ease, but extension, external rotation, and abduction are strongly resisted. Upon inspection and palpation the depression which normally exists behind the trochanter is lost and there is a decrease in the resistance of the soft parts in front, when palpated below the outer half of Poupart's ligament. This last sign, although rarely necessary for a diagnosis, may in obscure cases serve to differentiate a dislocation from fracture of the neck of the femur, since in the latter condition the sense of resistance upon palpation below Poupart's ligament is increased. The maintenance of the position of the limb, as described, depends, as was first pointed out by Bigelow, upon the tension of the untorn Y ligament. The gluteal fold is elevated and the buttock appears more prominent upon the injured side.

Upon palpation, the head of the bone can usually be felt in the buttock beneath the gluteus maximus muscle and above the tuberosity of the ischium. The head can be recognized in this situation upon flexing or rotating the limb. A very important point in the diagnosis is the position of the great trochanter, which is displaced backward and therefore lies farther from the iliac spine. Moreover, the trochanter rises above Nélaton's line. In the iliac form, this ascent amounts to from 3 to 7 cm. In the ischiatic form the trochanter rises from 2 to 3 cm. above Nélaton's line. These measurements indicate the real shortening of the limb. The *apparent* and *measured* shortening are difficult to

[1] L. A. Stimson, *loc. cit.*, p. 731.

determine accurately and are of no great moment in the diagnosis. The apparent shortening varies greatly in different cases. It is increased by flexion of the limb and also by adduction, and since the sound limb is frequently abducted in order to make place for its adducted fellow the apparent shortening may appear to be very marked indeed. Stimson says in reference to the measured shortening: [1]

If the head of the femur is displaced backward toward the spine of the ischium, the length of the limb measured in extension (if that is possible) from the anterior superior spine of the ilium to the knee or ankle will not be diminished, for the movement backward of the head has been at right angles to the line of measurement and has not brought the knee any nearer to the pelvis; but if the measurement is made while the thigh is flexed at a right angle, the measured length will be less by about two inches than that of the other limb in the same position, for now the measured line is nearly parallel to the direction of displacement. When the head is displaced upward as well as backward the difference in the amount of shortening in these two positions of the limb is much less, for the direction of the displacement deviates at about the same angle from the measured line in each attitude. Of course, in each limb the measured length is less when the thigh is flexed, but the difference in the comparative measurements of the two limbs is not affected in the high dislocations and is greatly affected in the low ones. In making measurements the two limbs must be symmetrically placed as regards flexion and adduction, and the fixed adduction of the injured limb sometimes interferes seriously with the accomplishment of this condition, for its knee occupies the position to which the other one should be brought, and, therefore, an equal adduction cannot be given to the sound limb without carrying its knee across at a higher or lower level, and thus giving it an unsymmetrical flexion. It must also be remembered that apparent symmetry of position is not sufficient; the symmetry must be real in that the angles of flexion and adduction *on the pelvis* are the same. Fortunately the exact determination of the shortening is not necessary to the diagnosis of the dislocation.

The *diagnosis*, as a rule, to which there are few exceptions, offers no great difficulty, the cardinal signs and symptoms being the fixed position of the limb in flexion, adduction, and internal rotation, and the impossibility of moving the limb in the opposite directions, the elevation of the trochanter above Nélaton's line and the complete loss of function in the extremity, together sometimes with the history of the accident. It rarely happens that confusion arises between fracture of the neck of the femur and posterior dislocation of the hip. The two conditions do not resemble each other. In fracture of the neck of the femur, internal rotation of the limb is a very rare condition, and in dislocations eversion is also rare. In fracture of the neck the limb lies straight, everted, and rarely actively mobile. In dislocation the trochanter is unduly prominent. In fractures it is flattened. In combinations of dislocation with fracture the head of the bone may sometimes be felt out of place and movements of the thigh

[1] L. A. Stimson, *loc. cit.*, p. 735, fifth edition, 1907.

will show that the displaced head does not take part in the motions. In cases of doubt the X-rays are a valuable aid.

Backward Dislocations with Eversion of the Limb.—These are exceedingly rare and depend for the unusual position of the limb, as was pointed out by Bigelow, upon rupture of the outer limb of the Y ligament, which in ordinary cases restrains and prevents outward rotation. The signs and symptoms may resemble those of an ordinary dorsal dislocation, except that the limb is rotated outward instead of inward. In another group described by Stimson he says that: [1]

> If the head of the femur has moved forward above the anterior inferior spinous process, they may differ widely, for the limb is then shortened by two inches, slightly adducted, more or less everted, and fully extended.

Fortunately for the diagnosis in these cases, the forward displacement of the head is so marked that the bone can be readily palpated. The limb is, moreover, fixed in its position to a degree which is not observed in fractures.

Reduction of Backward Dislocations.—The reduction of backward dislocations is made by traction aided by manipulation. The method most commonly in vogue is that of Bigelow. The patient is placed upon his back, the pelvis is fixed usually by assistants, or by a band of cloth stretched across the lower part of the abdomen, so that the pelvis is held firmly and cannot rotate. The surgeon flexes the injured limb to a right angle, thereby bringing down the head of the bone to the point opposite the rent in the capsule behind the acetabulum. The limb is then rotated inward and adducted in order to free the bone from the projecting rim of the acetabulum, when strong traction is made in a vertical direction. The head of the bone then, as a rule, slips into place, or the lifting of the limb may be followed by abduction and outward circumduction as it is called, with final extension, bringing the limb down parallel with its fellow. A caution is given by Stimson, that the reduction is to be effected, not by manipulation but by traction upward, since, if during the rotation and adduction traction is not maintained, the head of the bone may cause additional laceration of the soft parts, or may pass forward in the direction of the thyroid foramen. It is usually desirable to put the patient under a general anesthetic. The upward traction may be made by the surgeon directly with his hands as he grasps the flexure of the knee and the angle, or, as suggested by Stimson, a broad loop of gauze folded into a band may be passed beneath the flexure of the knee and over the surgeon's shoulders. The surgeon may thus lift strongly with his back, while the manipulations are made with the hands grasping the limb. Stimson's method of reduction, successful in nearly all backward dislocations of the hip, is described by him as follows: [2]

> A much more convenient plan, one which I have habitually employed for many years, is to place the patient, face downward, upon a table with his legs projecting

[1] L. A. Stimson, *loc. cit.*, p. 739, fifth edition, 1907.

[2] *Ibid.*, p. 743, fifth edition, 1907.

so far beyond the edge that the injured thigh hangs directly downward, while the surgeon grasps the ankle, the knee being flexed at a right angle. The other limb is held by an assistant. The weight of the limb now makes the needed traction in the desired direction, and the surgeon has only to wait for the muscles to relax and the bone to resume its place without further effort on his part than a slight rocking or rotation of the limb. Occasionally I have added the weight of a small sand bag at the knee, or have made sudden slight pressure at the same point. It will often succeed without anesthesia, and sometimes so quietly that there is no jar or sound indicating the return to place. In only two cases has it failed in my hands; both were then reduced by traction in the axis of the partly flexed limb. I presume that in both the bone had left the socket at its upper posterior segment—"iliac" dislocation.

Dorsal Dislocations with Eversion.—The everted dorsal dislocations with rupture of the outer limb of the Y ligament must first be converted into the ordinary dorsal form before reduction. In these it will be borne in mind that the head of the bone lies above the acetabulum, and in order to bring it into proper relation with the rent in the capsule the limb must be flexed, rotated inward, and adducted, whence it is replaced into the socket by direct traction upward with hand pressure upon the head of the bone.

Numerous other methods are described for the reduction of backward dislocations. They differ somewhat in detail, but the mechanism is the same in all. The simplest directions were those given by Bigelow. They are as follows: "1. Flex and forcibly lift. If this fails, 2. Flex and lift while abducting. If this fails it will be found that the rent in the capsule has been so enlarged that the first method may now prove successful."

FIG. 180.—OBTURATOR DISLOCATION OF THE HIP-JOINT. (Kindness of Dr. P. R. Bolton.)

Dislocations Downward and Inward.—Of these there are two varieties or two degrees of displacement. The head of the bone tears the capsule at its lower and inner part and slides inward, coming to rest upon the thyroid foramen, thus producing the *obturator or thyroid form of dislocation,* or passes still farther inward, sliding across the ramus of the pubes into the perineum, producing *the perineal form of dislocation.*

Thyroid Dislocations.—Thyroid dislocations of the hip are not very frequent. The perineal form is rare. In both forms the dislocations are produced by violence coming in a direction from behind forward, when the limb is in the position of flexion, abduction, and external rotation. The violence is usually external, as when a weight falls upon the back when the body is bent forward and the limb is in the above position, or as in falls from a height when the individual strikes the ground with the limb abducted and flexed. The dislocation may also be produced, as in a case reported by Corne and quoted by Stimson,[1] by simple abduction of the extended thigh. The individual was a drunken sailor whose thigh was forcibly abducted by his comrades. Stimson says that in another set of cases the mechanism of the dislocation is not entirely clear, as between forces acting upon the trochanter to push the head of the femur downward and inward, and exaggerated abduction by pressure forward of the outer part of the pelvis. The thyroid form may also occur as a secondary displacement of the dorsal variety.

FIG. 181.—ANTERIOR DISLOCATION OF THE HIP. (Kindness of Dr. P. R. Bolton.)

The *signs and symptoms* of thyroid dislocation are usually, that the limb is flexed, abducted, and more or less rotated outward, though Stimson states that the outward rotation may be slight or absent, or the limb may even be slightly rotated inward. There is apparent lengthening of the affected limb as the patient stands erect, on account of the downward tilting of the pelvis upon the injured side in order that the uninjured limb may be brought parallel with its abducted fellow. It is not easy in these cases to determine the comparative lengths of the two limbs accurately. If the injured limb be measured while flexed and abducted while the uninjured limb is measured while extended, there will be measured shortening upon the injured side, while if both are extended and the abduction of the injured limb is not marked, it may measure more than the other. Upon palpation the head of the bone can usually be felt by pressing the fingers upward and inward upon the inner aspect of the thigh toward the thyroid foramen. The hip is flattened; the trochanter less prominent

[1] L. A. Stimson, *loc. cit.*, p. 745.

than normal, since it is displaced downward and toward the median line. In some of these cases the patients have been able to walk with greater or less discomfort for a time after the accident. Important aids in the diagnosis are the attitude of the limb in flexion, external rotation and abduction, the impossibility to make complete extension and the limitation of adduction. Stimson [1] states that in the cases which he has seen "reduction was easily accomplished under ether, by increasing the flexion and rotation, making traction of the long axis of the limb and then lowering and rotating inward."

Perineal Dislocations.—In this rare form all the signs of thyroid dislocation are exaggerated; in addition the head of the bone can plainly be felt as a rounded, hard body in the perineum and the inward displacement may be so great as to compress the urethra and interfere with urination. Reduction can be effected under anesthesia by strong traction upon the limb in its abducted position and by direct pressure upon the head toward the cotyloid cavity combined with flexion.

Dislocations Upward and Forward (Suprapubic).—These are among the rarer dislocations of the hip. The head of the bone ruptures the capsule at its inner part, sometimes higher and sometimes lower, and may come to rest upon the horizontal ramus of the pubis at the ilio-pectineal eminence or still farther inward upon the pubic symphysis, the latter form being less common than the former. These dislocations occur when the body is suddenly bent backward, the thigh being fixed, though cases have been observed in which mere backward flexion of the trunk without fixation of the lower extremity has produced this form of dislocation.

FIG. 182.—ANTERIOR DISLOCATION OF THE HIP.
(Kindness of Dr. P. R. Bolton.)

The *signs and symptoms* of the ilio-pectineal form are as follows: The limb is markedly rotated outward, abduction is absent or slight, the limb is shortened, the head of the bone can be felt in the groin and overlying it in some cases passes the femoral artery, the pulsations of which can be felt, though the vessels may be displaced to the inner side. In some cases the head of

[1] L. A. Stimson, *loc. cit.*, p. 749.

the bone is still further displaced to the inner side, and in these the limb will be abducted, rotated outward, and flexed. The differentiation is readily made from an obturator dislocation by the presence of the easily palpable head in the groin. To this latter group is given the name of *pubic or suprapubic dislocation*, and in these the head is usually not only palpable but visible.

A few cases have been reported in which the head has been forced still farther upward beneath Poupart's ligament into the iliac fossa. In the intrapelvic forms, pressure symptoms may be produced upon the vessels and anterior crural nerve. The position of the limb in the ordinary cases of ilio-pectineal and pubic dislocations resembles that of fracture of the neck of the femur, but the differential diagnosis is easily made by recognizing the presence of the head of the bone in an abnormal position. Kocher's method of reducing these dislocations, as given by Stimson,[1] is as follows:

1. Traction in the axis of the limb as it lies, in order to bring the head below the brim of the pelvis. It is rarely necessary to aid this by increasing the extension, abduction, and outward rotation of the limb. By this means the posterior portion of the capsule is made tense, its point of attachment to the back of the neck of the femur is thereby made the center for the following movements:
2. Pressure with the hand upon the head of the femur to prevent its return upward during flexion. Sometimes this is sufficient to make reduction.
3. Flexion in order to relax the Y ligament; it should not be carried to a right angle, otherwise too much strain will be made upon the posterior portion of the capsule.
4. Rotation inward, by which the head is returned to the socket.

Dislocations Directly Upward (Supracotyloid).—These are such rare dislocations that I do not feel it is necessary to go into details in regard to them. The head of the bone lies below the anterior superior spine of the ilium. The position of the limb is one of outward rotation, abduction, and extension.

Dislocations Downward (Infracotyloid).—*Dislocation upon the Tuberosity of the Ischium.*—These dislocations may be produced by extreme flexion of the thigh merely, though Stimson states that exaggerated abduction followed by slighter flexion is also capable of producing it. The position of the limb is one of flexion and abduction. There may be slight internal or external rotation. The distance between the great trochanter and the crest of the ilium is increased and the buttock upon the affected side is more prominent than normal.

That form of dislocation in which the head of the bone is driven through the bottom of the acetabulum into the pelvic cavity has been mentioned when speaking of Fractures of the Pelvis.

Simultaneous Dislocation of Both Hips.—Simultaneous dislocation of both hips has been recorded in a moderate number of instances. Usually the dislocation differs in character upon the two sides. The injury has been caused in some instances by a heavy blow upon the back while the patient was standing

[1] L. A. Stimson, *loc. cit.*, p. 756.

with his thighs flexed and his body bent forward; the result was that a sidewise strain or twist was given to the body, so that one thigh was adducted while the other was abducted. Thus, upon one side, there will be produced a dorsal dislocation, and on the other a dislocation inward and forward.

Associated Injuries.—The associated injuries which may occur as complications of dislocations of the hip are numerous. The dislocation may be rendered compound, in which case the diagnosis is to be made by inspection. Fracture of the pelvis may be an associated injury and that may be combined also with fractures of the shaft of the femur. Such injuries are produced by very great degrees of violence. In the only case coming under my personal observation a little boy, who was run over by a locomotive, there was very extensive laceration of the muscles of the thigh and of the abdominal wall with evisceration. Death occurred about two hours after the injury. Fracture of the neck of the femur may occur as a part of the original injury, or be produced during efforts at reduction. The head of the femur has been fractured in a few instances. In a case quoted by Stimson, a very extensive fracture of the pelvis, the cotyloid cartilage was torn away from the fractured bone. In a very few cases of suprapubic and obturator dislocations the femoral vessels have been injured.

SPONTANEOUS, PATHOLOGICAL, VOLUNTARY AND RECURRENT DISLOCATION OF THE HIP

There are but two recorded cases of recurrent or habitual traumatic dislocations of the hip. One was observed by Bigelow and another was quoted by him from the report of a case by Dr. E. M. Moore. They are both described by Stimson.[1] In Bigelow's case the patient received a dorsal dislocation, and after he was able to be about again the dislocation recurred, though only partial. Subsequently he became able to dislocate and replace the head of the bone at will. In the second case, also a dorsal dislocation, the patient, a soldier, dislocated his hip in battle. It was pulled into place by his comrades, after which he continued on very arduous duty for a number of days. Subsequently he was able to dislocate his hip at will.

As a rare condition may be mentioned the dislocations of the hip and sometimes of other joints, nontraumatic in character, which can be produced at will by certain individuals, as the result, presumably, of an abnormal size or shape of the bones, or of notable relaxation of the whole or a portion of the capsular ligament of the joint. I saw one such individual who could dislocate his shoulder anteriorly and his hip upon the dorsum of the ilium. The dislocations were apparently incomplete. The man was a mountebank and juggler who made his living in part by his ability to throw his bones out of joint and replace them at will.

As the result of *destructive diseases* of the bones entering into the hip-joint, notably of tuberculosis, and in some cases of arthritis deformans and in tabes,

[1] L. A. Stimson, *loc. cit.*, p. 759.

dislocation of the head of the femur is observed as a part of the pathological lesion. The recognition of the dislocation is usually not difficult, and the destructive lesions of the bones or the changes in their shape are such that it is usually impossible to reduce and keep the bones in place. In some the dislocation depends solely upon destruction of the bones entering into the articulation; in others, as in arthritis deformans, it may depend in part upon such a new growth of bone that the articular surfaces no longer fit.

As the result of paralyses of the muscles, notably from poliomyelitis in children, dislocations of the hip may occur, which may depend either upon total paralysis of all the muscles surrounding the hip with consequent loss of support, or upon paralysis of one set of muscles and the unopposed action of another group which ends by pulling the bone out of its socket. In the case of the hip-joint, the adductor group are supplied by the obturator nerve arising from the lumbar plexus, while the gluteal group are supplied by branches of the sacral plexus. If the former group — namely, the adductors — paralyzed, the posterior muscles will pull the head of the femur upon the dorsum of the ilium. If, on the other hand, the adductors remain active, while the glutei are paralyzed, the dislocation will be forward and inward, usually of the obturator type. The dislocations which occur during prolonged illness and confinement to bed with the limb in one position occur more often in the hip than elsewhere. They have already been mentioned in Vol. I, under the head of Dislocations.

FRACTURES OF THE FEMUR

Fractures of the femur occur in the statistics of different observers with a frequency of from about four to six per cent of all fractures. For purposes of description it is customary to group fractures of the femur under fractures of the upper end of the bone, fractures of the shaft, and fractures of the lower end. Of the fractures of the upper end, fractures of the neck are the most common.

Fractures of the Neck of the Femur.—The neck of the femur forms an angle with the shaft which varies, as already stated, in the anatomical remarks at the beginning of this chapter, within rather wide limits, but is in the adult on the average about 130° and a very little less in old people. The angle is somewhat greater in infants. Fracture of the neck of the femur is essentially a lesion of old age and is more common among women than among men. Since the advent of the X-rays, it has been observed that fractures of the neck of the femur occur in children with considerable frequency—much more frequently indeed than was formely supposed, but since in many of these cases the fracture is incomplete or not attended by separation of the fragments, until the X-rays could be used to verify the diagnosis, a considerable number of such patients were treated for contusions and sprains of the hip. Be that as it may, the frequency of the fracture increases with advancing years, and is far more frequent after the age of sixty than before that time. It was formerly believed that in old age the angle made by the neck with the shaft approached more

nearly to a right angle, thus mechanically favoring fracture at this point. T idea is now abandoned since it is known that the angle diminishes very lit on account of advanced age. The true solution of the matter was first dem strated by Bigelow, who showed that the real cause of the weakness of the bo was due to a senile change in the bony structure, an osteoporosis, in which r

FIG. 183.—FRACTURE OF THE NECK OF THE FEMUR, SLIGHT UPWARD DISPLACEMENT OF THE SH X-ray. (New York Hospital collection.)

only does the cortical layer of the neck become thinner, but also there is absorption of many of the bony lamellæ of the spongy portion, and still m important, perhaps an absorption of the vertical plate of bone which, proceed from the head along the posterior surface of the neck, passes into the cancell tissue at the junction with the shaft, passing outward parallel with the anter surface of the neck and leaving a large portion of the great trochanter behi the posterior wall of the neck. In old people the absorption of this plate dense bone may be almost complete, thereby greatly diminishing the streng of the neck.

The diminished strength of the bone is the true explanation of the occurre of fractures of the neck of the femur from very slight degrees of violence, slight that a misstep, a stumble, or an effort to prevent a fall, or even in so

cases merely turning over in bed, may in the elderly produce a fracture of the neck of the femur.

In relation to fracture of the neck of the femur, the attachment of the capsular ligament is of interest. As was mentioned at the beginning of this chapter, the capsule is attached in front along the intertrochanteric line and thus passes to the junction of the head with the neck. Posteriorly, on the other hand, the capsule is attached to the neck itself at a little distance from its outer limit, leaving a space of about half an inch uncovered by capsule, constituting about one quarter the length of the neck. Thus a purely extracapsular fracture of the neck does not occur. The synovial membrane of the joint is not co-extensive with the capsular ligament, but is reflected from the neck of the femur some little distance nearer to the head, so that a fracture of the neck may be intrascapular but extra-articular.

In regard to the prognosis of fracture of the neck of the femur, the blood supply of the bone is a consideration of importance. At the time when frac-

FIG. 184.—FRACTURE OF THE NECK OF THE FEMUR. Splitting of the great trochanter. X-ray. (New York Hospital collection.)

tures of the neck of the femur are most likely to occur, the head of the bone receives no blood supply from the ligamentum teres, but depends for its nutrition upon the blood-vessels running in the dense periosteum of the neck. These

are most abundant upon the upper portion of the neck, and run toward the head to enter it by the numerous foramina found in this situation. In fractures at the junction of the neck with the shaft, this periosteum is but little injured as a rule, and may even remain untorn. In fractures of the narrow portion of the neck, the vitality of the head of the bone, and the prognosis as regards union between it and the shaft, depend very largely upon whether this blood supply is maintained through untorn portions of periosteum. If it is ruptured completely, failure of union will very likely occur. If, on the other hand, it is preserved, union will probably result and in some instances may become bony. It was formerly believed that bony union in fractures of the neck of the femur was rare, but it is now known that such is not the case. Fractures of the narrow part of the neck may even unite by bone, more rarely in the aged than in the young. These conclusions are based largely upon clinical experience, upon pathological examination, and upon the demonstration of such bony union by means of X-ray pictures.

The fractures of the narrow part of the neck are those most commonly produced in the elderly by slight degrees of violence. Fractures of the base of the neck, on the other hand, are seen quite commonly in younger persons, and result from more severe degrees of violence, blows or falls upon the trochanter, and other causes to be mentioned. In fractures of the base of the neck an angular deformity is usually produced by crushing of the posterior portion of the neck, the apex of the angle being directed forward, or in other cases the neck penetrates and crushes the great trochanter. In some cases such penetration may cause extensive splitting of the trochanter, with some degree of impaction, or in others, although the fragments are interlocked by the irregularities in the fractured surface, such interlocking is not firm, is readily separated, and does not constitute true impaction (Stimson).

The Causes of Fracture of the Neck of the Femur.—The most important predisposing causes are the senile changes in the bone, the result of old age. The active causes are very varied. In the aged the causes are, as stated, often very slight. A misstep, as in descending the stairs and stepping down two steps instead of one, a sudden twisting of the trunk, while the thigh remains fixed, or a fall such as might be produced when an old woman catches her toe in a rug and falls to the floor. In the young and middle-aged the fractures are usually produced by much greater degrees of violence, such as falls upon the hip while skating, falls from a height, striking upon the trochanter, or other severe degrees of violence. Stimson [1] states that:

> In the aged it is easy to produce a fracture either at the base or at the narrow part of the neck by adduction, abduction, or rotation, and that, further, some of these fractures are caused by the tension of the Y ligament by hyperextension and abduction of the limb, and by this same mechanism fractures at the base of the neck or at the narrow part may be produced.

[1] L. A. Stimson, *loc. cit.*, p. 320.

The Lesions of Fracture Through the Neck Proper.—The fracture may take place at any point between the junction of the neck with the head and of the neck with the shaft. The line of fracture may be transverse, oblique or irregular, and may or may not be associated with crushing of the neck. As stated, the crushing usually affects the posterior and lower portion of the neck, so that an angular deformity is produced with its apex in front and above. This common peculiarity accounts in part for the eversion of the limb in fractures of the neck of the femur. In a considerable proportion of cases, according to Stimson, the periosteum remains untorn over some portion of the line of fracture. This fact is very important in relation to the handling of these patients and to the treatment. All motions at the hip-joint should be avoided as far as possible in transportation, and during the examination the utmost care should be taken not to cause additional displacement. If treated with great gentleness, the fragments of bone may remain in contact and the periosteum be at least in part preserved, thereby greatly improving the prognosis, or, on the other hand, the attempt on the part of the patient to use the injured limb or motions made by the surgeon or others, in transporting and examining the patient, may totally displace the fragments, rupture the periosteum completely, and even tear the joint capsule, thus increasing the injury and rendering the prognosis as to union much worse. (See, however, below.)

Separation of the Epiphysis.—The line of the epiphyseal cartilage runs through the junction of the head with the neck. Union takes place between the ages of seventeen and twenty-one years. Formerly this was believed to be a rather rare injury. At the present time, largely through the use of the X-rays, it is known to be quite common. It occurs with considerable frequency in young boys and girls, sometimes from very moderate degrees of violence. The symptoms are moderate pain, eversion, and loss of function. It happens quite often that the nature of the injury is not recognized and that these patients are treated for a sprain or contusion of the hip. The loss of function in the limb may be partly recovered from at a very early date, so that these children may wrongly be permitted to walk with the production of considerable displacement of the neck with reference to the epiphysis, and if unrecognized these children grow up with coxa vara, with a permanent limp and some disability. Whitman has reported a large number of these cases in which he has corrected the displacement and produced a very perfect result by an open incision, exposing the neck of the bone, chiseling away a small piece, so that the chisel can be introduced between the neck and the epiphysis and the head pried into place with the chisel. The limb is then put up in a fixed dressing in such a position as to keep the fragments in contact—namely, in abduction. The results in the cases which he has shown at the New York Surgical Society are very perfect. In boys who have reached the age of fifteen or sixteen, and who are not operated upon until some time after the injury, the results are good, but not as perfect as is the case with young children.

The symptoms of separation of the epiphysis are usually loss of function

in the limb, eversion, sometimes shortening. In some of the cases the early symptoms are slight. Whitman believes that the separation is at first only partial, the early symptoms being merely a limp with some stiffness and pain of the hip-joint, and that later, after use or some slight violence, distinct symptoms of fracture appear with shortening. Whitman treats fracture of the neck of the femur, both in children and adults, by forcible abduction of the limb to an angle of 45°, breaking up any existing impaction to do so, and immobilizing the limb in this position by plaster of Paris. The displacement is thus more or less perfectly reduced and the fragments kept in contact. The steps of the method are traction, abduction, flexion, lifting the trochanter forward, rotation to correct eversion or inversion, immobilization. The results are good in suitable cases.

Fractures of the Base of the Neck.—These constitute a large group of fractures, seen during early adult life and middle age, and also in elderly persons. The violence is usually more severe than is the case with fractures of the narrow part of the neck. The line of fracture in the most common type follows rather closely the junction of the neck with the shaft, or, as Stimson says,[1] "it coincides with the spiral line in front and the intertrochanteric line behind, as they pass between the great and lesser trochanters." The fracture may begin above at the junction of the neck with the shaft in such a manner as to include the lesser trochanter in the upper fragment, or it may pass outward and downward including the great trochanter. Stimson further states that[2] "in the majority of cases other lines of fracture traverse one or both trochanters, splitting off one or two pieces, usually from the posterior surface of the great trochanter or comminuting it completely." The most ordinary form of displacement is, as already stated, that in which at the point of fracture the head and neck are bent backward, so that the amount of crushing on the posterior surface greatly exceeds that in front, producing the angular deformity already described. A considerable degree of impaction may exist in these cases, although Stimson says[3] that impaction in the sense of penetration and fixation is, in his opinion, uncommon, while crushing with or without penetration is the rule. In a few reported cases the crushing has taken place to a greater extent in front than behind, so that instead of eversion there is inversion of the limb. These cases are, however, rare. In most instances carefully taken X-ray pictures will demonstrate the direction of at least the most important lines of fracture as well as the character and extent of the displacement. In some instances where shortening was absent and the only sign of fracture was eversion, probably due chiefly to relaxation of the muscles and where no measured shortening was present, the X-rays have in my experience, in a number of instances, demonstrated the presence of a fracture without displacement with great clearness.

Repair in Fracture of the Neck of the Femur.—Fractures of the narrow portion of the neck are far more likely to be followed by failure of union

[1] L. A. Stimson, *loc. cit.*, p. 323. [2] *Ibid.*, p. 325. [3] *Ibid.*, p. 326.

than fractures at the base of the neck. In the former group the probability of union will depend largely upon whether or not the periosteum is completely torn between the two fragments. If it is, union is improbable. If not, close fibrous union, or, in exceptional cases, bony union, may be obtained by proper treatment, so that the individual will have good use of the limb. In some cases extensive absorption of bone takes place, sometimes the neck almost entirely disappears, and sometimes the head undergoes partial or complete absorption. In fractures at the base of the neck there is usually the production of considerable masses of new bone from the periosteum of the several fragments. In some cases of this kind, although no union may occur, the production of bone may be so great that between the base of the neck and the trochanter and shaft a sort of false joint is formed, which may afford considerable support to the head and proximal fragment of the neck. Thus Stimson figures a case of this kind, a fracture of the base of the neck in which the production of new bone was so extensive that the fragments, although not united, became interlocked and the patient was able to use the limb with a fair degree of usefulness. Another similar specimen is in the Anatomical Laboratory of the College of Physicians and Surgeons of Columbia University. In this case a large mass of new bone has been produced, such that it closely grasps the base of the neck—i. e., the proximal fragment—although the head and neck are quite easily rotated in this newly formed socket. In this case the history of the patient is unknown. (See Fig. 185.)

FIG. 185.—FRACTURE OF THE NECK OF THE FEMUR. The neck is driven into the upper end of the shaft and trochanter. There is nonunion, but the formation of new bone and of osteophytes around the base of the neck has formed a false joint in which the neck and head can be rotated slightly. (Anatomical Department, Columbia University.)

While it is quite easy to differentiate fractures of the narrow part of the neck from fractures of the base of the same by means of the X-rays, it would be difficult to form on the data, thus furnished alone, any probable conclusion as to whether union would or would not occur, except that in the cases with little or no displacement where the picture seems to

show the fragments in contact, careful immobilization for a number of weeks would probably result in union, whereas if the fragments were entirely separated and the displacement marked, such union would be more doubtful. The following conclusions in regard to union of these fragments are drawn by Stimson:[1]

> The facts in our possession are: (1) That bony or close fibrous union after *fracture through the neck* is possible; (2) that the preservation of enough of the periosteum of the neck to make a vigorous vitality of the head probable is probably common; and (3) that the primary displacement usually does not separate the fractured surfaces, so that if it is not increased by early attempts to use the limb or, more rarely, by the action of the muscles in the absence of proper retention, the conditions for reunion are favorable. We also know that fair usefulness of the limb, even after union has failed, is possible; and it has not been proved that this usefulness is greater or more probable if the attempt to secure union has not been made.

Fractures of the base of the neck, notably if the fragments are not separated, are much more apt to unite than fractures of the narrow portion of the neck. The older the patient, the less in general is the probability of union in fractures of the narrow part of the neck.

Signs and Symptoms of Fracture of the Neck of the Femur.—The diagnosis of fracture of the neck of the femur is in the majority of cases quite simple; only exceptionally are we in doubt as to the existence of fracture, and in the doubtful cases the X-rays will usually render the diagnosis clear. The prominent signs and symptoms are, loss of function in the extremity, eversion of the limb, shortening of the limb, and elevation of the trochanter. As has already been suggested, when an elderly person stumbles, slips, or falls, be the violence however slight, and is then unable to use one lower extremity, the diagnosis of fracture of the neck of the femur is exceedingly probable. If, in addition, upon examining the patient the limb is found extended, the foot everted, with total loss of power in the extremity, the diagnosis is almost certain, or at least so highly probable that in the absence of other definite signs and symptoms we are not only justified but in duty bound to treat the injury as though the neck of the femur were fractured.

As stated, it is a general rule that patients with fracture of the neck of the femur are totally unable to use the limb. They cannot stand upon it, nor can they move it in bed. Exceptions, however, occur. It sometimes happens that a patient with this injury is able slowly to flex the thigh upon the pelvis, though as he does so he may have to assist himself with his hands in pulling up the limb. The knee, however, continues to flex itself more and more; the foot upon the affected side can by no means be raised from the bed. In other cases, as pointed out by Whitman, in young persons with fracture of the neck of the femur, the disability is relatively slight, so that they may even be able to walk after a few days. In these, however, a serious condition sometimes follows—namely, that

[1] L. A. Stimson, *loc. cit.*, p. 331.

the weight of the body causes the neck of the femur to assume a position at right angles to the shaft, or even a lesser angle, producing the so-called "traumatic coxa vara," elsewhere described.

There have come under my observation a small number of cases of undoubted fracture of the neck of the femur, probably of the base, with impaction, where the patient walked for several days before coming into the hospital and where the signs of fracture seemed quite clear. These cases were, however, seen in Bellevue Hospital many years ago, before the X-rays were known; still, shortening and eversion with other signs were present. In a number of cases in young persons it has been observed that following the injury they were able to use the limb, and even walk to a certain extent for a number of days, when suddenly or gradually more definite signs of fracture appeared, including shortening and marked disability. It is better in all cases of doubt between fracture of the neck and contusion of the hip to treat the case as a fracture. It is to be borne in mind, however, that a severe contusion of the hip may produce ecchymosis and even eversion of the limb from relaxation of the muscles. The X-rays are an invaluable aid in doubtful cases.

The pain accompanying fracture of the neck of the femur is, in many cases, not marked. It is usually present to some extent and may be referred to the seat of the injury or to the groin and inner surface of the thigh. Pain on crowding the trochanter inward may be present or absent, and the same is true of pushing the entire extremity upward.

Eversion of the Limb.—This sign is so characteristic that in many instances a probable diagnosis can be made merely by inspection. The degree of eversion varies a good deal in different cases. Where the limb is completely everted so that the foot rests entirely upon its outer border, the condition may be due to complete separation between the fragments, and yet it is observed also when the fragments are interlocked and where the angular displacement at the point of fracture is hardly sufficient to account for it. It is to be borne in mind that the degree of eversion varies much in different cases, apparently without reference to the actual relation between the bony fragments. Eversion may also be present from a contusion of the hip, as already stated. In some cases the eversion is so slight that it is noticeable only upon comparing the sound with the injured limb, or, as Bigelow pointed out, it can best be recognized by observing to what extent inversion is limited upon the injured as compared with the sound side. In addition to eversion, the limb is slightly flexed and abducted. The upper part of the thigh in front and to the outer side often appears fuller than normal, and ecchymosis on the outer aspect of the limb is a sign frequently observed after a day or a few days.

Shortening of the Limb.—The shortening observed in fracture of the neck of the femur varies much in different cases. It may be due to actual overriding, and if present from this cause will vary in amount from a distance so small as to be difficult of measurement to two or more inches. In other cases, without separation, it is due to a change in the angle between the shaft and the neck,

and in these it is often very slight, perhaps too slight to measure. In fractures of the narrow portion of the neck it frequently happens that the shortening is absent at first, and after hours, or days, slowly or suddenly shows a marked increase. In these fractures the shortening is apt to be less than in the cases of fracture at the base of the neck with complete separation and overriding, and in the former group it is said rarely to exceed an inch or an inch and a quarter.

FIG. 186.—FRACTURE OF THE FEMUR AT THE LEVEL OF THE LESSER TROCHANTER. Union with angular deformity. (Anatomical Laboratory of the College of Physicians and Surgeons of Columbia University.)

The detection of shortening of the femur depends upon comparative measurement of the two limbs. Owing to the fact that the bony prominences from which the measurements must be taken are more or less covered with soft parts, and that the changes in the position of the limbs, abduction and adduction, cause a variation in the comparative measurements, it is very desirable to make these measurements with care. The patient should be examined upon a table, if possible, or upon a smooth, firm bed. The two limbs must be placed as nearly as possible in identical positions with reference to the pelvis, equally abducted or adducted as the case may be. In order to accomplish this the patient is placed upon his back and a yard stick, or a ruler graduated in inches, is placed across the body upon the anterior superior spine of the ilium of either side. From the middle point of the stick a string is brought down between the feet at right angles to the stick. The limbs are then placed equidistant from the string, and every effort should be made to avoid any tilting or displacement of the pelvis during the examination. The measurements are then made upon the two sides of the body from the anterior superior spine of the ilium by means of a steel tape to the tip of the inner or outer malleolus, or, as some surgeons prefer, the measurements may be made from below upward—that is to say, from the malleolus to the spine of the ilium. The measurements upon the two sides are then compared and it is well to repeat them, or sometimes to have them made by two different individuals. Upon the fractured side of the extremity will usually be found to measure less than the

uninjured limb. If it be found impossible while the string is maintained at right angles to the stick passing across the spine of the ilia to bring both ankles close to the string, the extremities must be equally adducted or abducted before the measurements are made.

An accompaniment of the shortening in fractures of the neck of the femur is the sign pointed out by Allis—namely, that the fascia lata is relaxed on the outer surface of the thigh as compared with the sound side. The relaxation may be best appreciated upon the outer surface of the thigh above the knee-joint. The same relaxation may be detected between the spine of the ilium and the trochanter.

Bryant's Ilio-femoral Triangle.—A plan devised by Mr. Bryant for detecting shortening in fracture of the neck of the femur is as follows: The patient is placed upon his back on a level surface and the two lower extremities are carefully arranged as in the former method of measurement, so that they occupy the same position with reference to the pelvis. A perpendicular is then dropped through the anterior superior spine of the ilium to the supporting surface. Such a perpendicular may be a tapeline, or, what is more convenient, the straight edge of a yardstick, or sawn piece of board, or the like. Measurement is then made from a point on the stick directly above the upper limit of the trochanter downward to the trochanter itself. This distance amounts in the normal adult to about two and a half inches. In fractures of the neck of the femur with shortening, the distance will be decreased upon the injured as compared with the sound side. (See diagram, Fig. 187.) The relations of the upper border of the trochanter to Nélaton's line, as described under Dislocations, may also be used, but it is less accurate than either of the two former methods. By traction downward upon the extremity the shortening may be overcome in some instances, or at least diminished. Stimson considers that the fear of causing separation of the fragments by such traction is exaggerated, since the penetration of the bones is at right angles to the line of traction, and he considers that rotary movements of the shaft are much more likely to cause such separation.

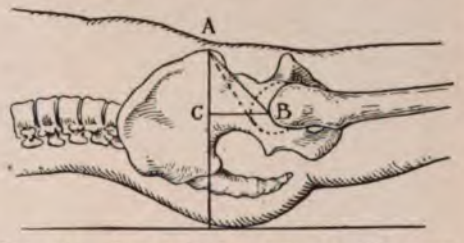

FIG. 187.—BRYANT'S ILIO-FEMORAL TRIANGLE. *A*. Anterior superior spine of the ilium. *B*. Great trochanter. *A–C*. Vertical line from which at *C* is measured the distance to the top of the trochanter.

Crepitus.—This sign is occasionally observed in fractures of the neck of the femur while making the examination of the limb, either by gentle rotary movements, or by pulling upon it in its long axis, or by gentle flexion. It is not a sign which should be sought for energetically in these cases, lest the bones, if interlocked, should be broken apart, thereby diminishing the chances of firm union. It may be elicited in some cases by gentle flexion and rotation of the limb, but unless it is perceived upon very slight and gentle movements, it is

best not sought for, the diagnosis in most cases being entirely plain by other signs, and where the actual lesion is in doubt, the X-rays are a much safer and better means of diagnosis.

Other signs and symptoms observed are an increased resistance to pressure over the hip-joint in the outer portion of Scarpa's triangle. Normally, pressure in this region with the fingers meets with only moderate resistance and is not accompanied by pain. In fracture of the neck of the femur, notably in those cases in which, without separation of the fragments, there is an anterior angular displacement, pressure in this region causes pain, and a firm resistance can sometimes be detected. In very thin subjects, even a distinct bony projection may be recognized. In certain cases when the trochanter is extensively split or splintered by penetration of the neck into its substance, palpation will show an increase in breadth, or possibly irregularity in outline of this portion of the bone.

FIG. 188.—FRACTURE OF THE BASE OF THE NECK OF FEMUR IN CHILD. (New York Hospital collection.)

A recognition by palpation of the trochanter and rotation of the shaft of the bone of the fact that the movement takes place about a shortened axis is of diagnostic value only when there is a complete separation between the neck and the shaft, in which case rotation of the limb may take place around the long axis of the femur, and such rotation may sometimes be appreciated by the fingers placed upon the trochanter. Instead of moving up and down it may be felt simply to rotate under the fingers, or in other cases vertical pressure upward upon the trochanter will not, as it normally should, cause inversion of the foot.

THE DIFFERENTIAL DIAGNOSIS OF FRACTURE OF THE NECK OF THE FEMUR.—While in a considerable number of cases it is possible by ordinary methods of examination, as described, to recognize the presence of fracture of the neck of the femur with great ease, and even to discover whether the fracture is of the narrow portion of the neck or of its base, yet in some cases the signs and symptoms are slight and obscure. In these the X-rays furnish invaluable aid in the differentiation. Certain other conditions are sometimes confounded with fracture of the neck of the femur. Dorsal dislocation of the ilium is

attended by flexion and inversion with fixation of the limb in certain directions, while in others motion may readily be made. The head of the bone can usually be felt beneath the gluteus maximus in the ordinary cases with inversion. In the dislocated cases with eversion the head of the bone can usually be palpated in the groin or upon the pubes. Fracture of the acetabulum with penetration of the head into the pelvis can be differentiated from fracture of the neck by

FIG. 189.—X-RAY PICTURE OF FRACTURE OF THE BASE OF THE NECK OF THE FEMUR IN AN ADULT. (New York Hospital collection.)

means of the X-rays. Fractures lower down in the shaft of the bone are usually readily detected by the presence of the ordinary signs of fracture in the shafts of long bones, mobility, crepitation and localized pain, and tenderness. The trochanter does not move when the shaft is rotated. Before examining the case it is always wise to inquire as to the history of former injuries of the hip and thus to eliminate possible errors, as, for instance, the presence of shortening. It is, nevertheless, possible for very good surgeons to mistake a fracture of the neck of the femur with inversion for a dorsal dislocation upon the ilium, especially if the case is not seen for sometime and where much new bone has been thrown out with inflammatory infiltration of the surrounding soft parts. I have seen a very distinguished surgeon indeed, in doubt as to the condition

are most abundant upon the upper portion of the neck, and run toward the head to enter it by the numerous foramina found in this situation. In fractures at the junction of the neck with the shaft, this periosteum is but little injured as a rule, and may even remain untorn. In fractures of the narrow portion of the neck, the vitality of the head of the bone, and the prognosis as regards union between it and the shaft, depend very largely upon whether this blood supply is maintained through untorn portions of periosteum. If it is ruptured completely, failure of union will very likely occur. If, on the other hand, it is preserved, union will probably result and in some instances may become bony. It was formerly believed that bony union in fractures of the neck of the femur was rare, but it is now known that such is not the case. Fractures of the narrow part of the neck may even unite by bone, more rarely in the aged than in the young. These conclusions are based largely upon clinical experience, upon pathological examination, and upon the demonstration of such bony union by means of X-ray pictures.

The fractures of the narrow part of the neck are those most commonly produced in the elderly by slight degrees of violence. Fractures of the base of the neck, on the other hand, are seen quite commonly in younger persons, and result from more severe degrees of violence, blows or falls upon the trochanter, and other causes to be mentioned. In fractures of the base of the neck an angular deformity is usually produced by crushing of the posterior portion of the neck, the apex of the angle being directed forward, or in other cases the neck penetrates and crushes the great trochanter. In some cases such penetration may cause extensive splitting of the trochanter, with some degree of impaction, or in others, although the fragments are interlocked by the irregularities in the fractured surface, such interlocking is not firm, is readily separated, and does not constitute true impaction (Stimson).

The Causes of Fracture of the Neck of the Femur.—The most important predisposing causes are the senile changes in the bone, the result of old age. The active causes are very varied. In the aged the causes are, as stated, often very slight. A misstep, as in descending the stairs and stepping down two steps instead of one, a sudden twisting of the trunk, while the thigh remains fixed, or a fall such as might be produced when an old woman catches her toe in a rug and falls to the floor. In the young and middle-aged the fractures are usually produced by much greater degrees of violence, such as falls upon the hip while skating, falls from a height, striking upon the trochanter, or other severe degrees of violence. Stimson [1] states that:

> In the aged it is easy to produce a fracture either at the base or at the narrow part of the neck by adduction, abduction, or rotation, and that, further, some of these fractures are caused by the tension of the Y ligament by hyperextension and abduction of the limb, and by this same mechanism fractures at the base of the neck or at the narrow part may be produced.

[1] L. A. Stimson, *loc. cit.*, p. 320.

sified by Kocher under the name fractura pertrochanterica. Stimson [1] defines this group of cases as those in which

The line of fracture begins at or near the lower part of the junction of the neck and shaft and passes through or close below the great trochanter, dividing the bone into two parts, of which the upper is formed by the head, neck, and upper part of the trochanter. The line of fracture may be oblique from within outward and upward, or from behind upward and forward. The line of division between these and the subtrochanteric fractures, the highest of the fractures of the shaft, is marked by the trochanter minor, which also establishes an important clinical difference, depending upon the action of the psoas-iliacus, which is attached thereto. Its action in fractures below that point is to flex the upper fragment.

These fractures are infrequent; the most characteristic sign, according to Stimson, is a prominent angle in front with pain on pressure in the groin with shortening and eversion and a possible failure of the trochanter to rotate with the remainder of the bone.

Fracture of the Trochanter Alone.—This is a rare injury caused usually by direct violence to the trochanter, occasionally by muscular action. The fragment usually remains more or less in position on account of the dense fibrous attachments surrounding it, but may be felt to move upon the shaft of the bone. There is localized pain and tenderness at the seat of fracture; the X-rays would render the diagnosis quite clear.

Fracture of the Lesser Trochanter.—This very rare injury may be produced by muscular action, or occasionally exists as a complication of fracture of the neck of the femur. The fracture as such would hardly be recognized by ordinary methods of examination and probably would require the use of the X-rays for an accurate diagnosis.

WOUNDS OF THE HIP-JOINT

Incised, stab, and contused and lacerated wounds of the hip-joint scarcely occur as isolated injuries, the joint being surrounded by so many important structures and so deeply placed. Gunshot wounds of the hip-joint occur occasionally in battle, though as isolated injuries they are exceedingly rare. In a general way the diagnosis of a gunshot wound of the hip-joint must be made upon anatomical grounds from the point of entrance and the track of the bullet. In the observed cases the wound of the joint has been complicated by very serious injuries, such as comminution of the head of the bone, fractures of the pelvis, injuries of the blood-vessels, etc., and in the complicated cases the symptoms produced by the associated injuries will usually overshadow in importance those of the joint itself. Aside from the complications, the opening of the joint by the bullet may or may not be serious, according to whether the wound remains clean or becomes infected. The prognosis is of necessity grave in the latter case. The X-rays are of course a valuable aid in cases of lodgment of the bullet.

[1] L. A. Stimson, *loc. cit.*, p. 344.

in the limb, eversion, sometimes shortening. In some of the cases the early symptoms are slight. Whitman believes that the separation is at first only partial, the early symptoms being merely a limp with some stiffness and pain of the hip-joint, and that later, after use or some slight violence, distinct symptoms of fracture appear with shortening. Whitman treats fracture of the neck of the femur, both in children and adults, by forcible abduction of the limb to an angle of 45°, breaking up any existing impaction to do so, and immobilizing the limb in this position by plaster of Paris. The displacement is thus more or less perfectly reduced and the fragments kept in contact. The steps of the method are traction, abduction, flexion, lifting the trochanter forward, rotation to correct eversion or inversion, immobilization. The results are good in suitable cases.

Fractures of the Base of the Neck.—These constitute a large group of fractures, seen during early adult life and middle age, and also in elderly persons. The violence is usually more severe than is the case with fractures of the narrow part of the neck. The line of fracture in the most common type follows rather closely the junction of the neck with the shaft, or, as Stimson says,[1] "it coincides with the spiral line in front and the intertrochanteric line behind, as they pass between the great and lesser trochanters." The fracture may begin above at the junction of the neck with the shaft in such a manner as to include the lesser trochanter in the upper fragment, or it may pass outward and downward including the great trochanter. Stimson further states that[2] "in the majority of cases other lines of fracture traverse one or both trochanters, splitting off one or two pieces, usually from the posterior surface of the great trochanter or comminuting it completely." The most ordinary form of displacement is, as already stated, that in which at the point of fracture the head and neck are bent backward, so that the amount of crushing on the posterior surface greatly exceeds that in front, producing the angular deformity already described. A considerable degree of impaction may exist in these cases, although Stimson says[3] that impaction in the sense of penetration and fixation is, in his opinion, uncommon, while crushing with or without penetration is the rule. In a few reported cases the crushing has taken place to a greater extent in front than behind, so that instead of eversion there is inversion of the limb. These cases are, however, rare. In most instances carefully taken X-ray pictures will demonstrate the direction of at least the most important lines of fracture as well as the character and extent of the displacement. In some instances where shortening was absent and the only sign of fracture was eversion, probably due chiefly to relaxation of the muscles and where no measured shortening was present, the X-rays have in my experience, in a number of instances, demonstrated the presence of a fracture without displacement with great clearness.

Repair in Fracture of the Neck of the Femur.—Fractures of the narrow portion of the neck are far more likely to be followed by failure of union

[1] L. A. Stimson, *loc. cit.*, p. 323. [2] *Ibid.*, p. 325. [3] *Ibid.*, p. 326.

es at the base of the neck. In the former group the probability of depend largely upon whether or not the periosteum is completely n the two fragments. If it is, union is improbable. If not, close n, or, in exceptional cases, bony union, may be obtained by proper o that the individual will have the limb. In some cases ex- orption of bone takes place, he neck almost entirely disap- sometimes the head undergoes omplete absorption. In frac- base of the neck there is usu- duction of considerable masses e from the periosteum of the ments. In some cases of this igh no union may occur, the of bone may be so great that base of the neck and the tro- shaft a sort of false joint is ich may afford considerable the head and proximal frag- neck. Thus Stimson figures is kind, a fracture of the base in which the production of as so extensive that the frag- ough not united, became in- d the patient was able to use th a fair degree of usefulness. ilar specimen is in the Ana- oratory of the College of Phy- Surgeons of Columbia Uni- this case a large mass of new been produced, such that it ps the base of the neck—i. e., al fragment—although the ck are quite easily rotated in formed socket. In this case of the patient is unknown. 85.)

FIG. 185.—FRACTURE OF THE NECK OF THE FEMUR. The neck is driven into the upper end of the shaft and trochanter. There is nonunion, but the formation of new bone and of osteophytes around the base of the neck has formed a false joint in which the neck and head can be rotated slightly. (Anatomical Department, Columbia University.)

t is quite easy to differentiate the narrow part of the neck res of the base of the same by e X-rays, it would be difficult to form on the data, thus furnished robable conclusion as to whether union would or would not occur, in the cases with little or no displacement where the picture seems to

relaxation of the capsule, together with muscular action, may in certain cases determine a dislocation of the joint, as elsewhere described.

The characters of the several forms of acute infectious inflammation of the hip-joint are as follows: In general in those cases which develop as complications of acute infectious diseases, the joint involvement occurs either at the height of the disease or during convalescence. The localized symptoms of joint infection often appear insidiously, with only moderate pain and limitation of motion in the hip, sometimes with an increase in the constitutional symptoms. In the majority of instances the exudate is serous or sero-fibrinous, occasionally purulent from the start. The amount of periarticular swelling and infiltration varies a good deal in the same and in different types of infection. The disturbance of function in the hip-joint itself is often very marked. In the more severe cases in which the exudate is of a distinctly purulent character, a panarthritis with destruction of the cartilages, perforation of the joint capsule, and the formation of abscesses in the soft parts of the thigh, either in front or behind, may form a very threatening or even a fatal condition.

Gonorrheal inflammation of the hip-joint is one of the rarer localizations of the disease. Here, as elsewhere, the exudate may be serous, sero-fibrinous or contain a greater or less number of pus cells. In the hip-joint the disease is apt to run a protracted and severe course, frequently ending in ankylosis or in a greater or less limitation of motion in the hip.

Typhoid inflammation of the hip-joint is usually characterized by rather an insidious course, and may be followed, unless the case be carefully watched and the limb placed in a position unfavorable for dislocation, by more or less complete luxation of the hip-joint.

The *syphilitic inflammations* of the hip in the acquired form of the disease are usually of a mild character in the early stages and in adults. As the result, however, of hereditary syphilis in children, a destructive type of inflammation may occur.

Acute polyarticular rheumatism may have the hip-joint as one of its localizations. For the signs and symptoms in detail, the reader is referred to works on general medicine. It is, however, to be borne in mind, that, as was stated under Joint Inflammations of the Upper Extremity, many cases diagnosticated as acute articular rheumatism are of a distinctly infectious character, due to one or other form of microbe. The high fever, the sweating, and the polyarticular character of the lesion usually suffice for a diagnosis. Marked leucocytosis may occur with complicating endocarditis, etc., or high fever. (See appendix)

The inflammations of the hip-joints which occur in the course of *acute exanthemata* in children are usually of a rather mild type and are seldom attended by destruction or ankylosis of the joint, though in some cases subluxation may occur. It is to be borne in mind that among children gonorrheal infection of joints is by no means a rare lesion and may even occur, as was elsewhere stated, without any apparent affection of the genito-urinary tract.

Coxitis as the Result of Direct Infection.—Infections of the hip-joint, the result of open wounds and of suppurative processes in the vicinity of the joint, are usually of a grave and destructive character, accompanied by severe symptoms of sepsis and by death in a considerable proportion of cases. The signs and symptoms of invasion of the hip are not hard to recognize. In the case of open wounds a discharge of synovial fluid will occur, at first only slightly cloudy, subsequently distinctly purulent in character. The pain upon moving the joint is intense, and the signs of inflammation of the soft parts (redness, swelling, and heat) are usually quite marked. In these cases the abscess which forms, if the wound be not widely opened, usually presents in Scarpa's triangle at the front of the joint. In the worst type of cases a panarthritis occurs with invasion of the soft parts of the limb and burrowing of pus in the intermuscular planes. The only hope of saving life in these cases consists in early and extensive operation, or eventually in amputation at the hip-joint.

The *diagnosis* of the presence of acute inflammation of the hip-joint is sufficiently simple. The character of the infection is best determined, as was already stated, by aspiration of the exudate and culture of the contained bacteria, as well as by the study of the constitutional symptoms.

Coxitis as the Result of Acute Osteomyelitis.—The hip-joint may become infected in the course of acute osteomyelitis involving either the pelvis or the femur. In the cases originating in the femur, the disease most commonly affects the diaphysis and the neck of the bone, less commonly the epiphysis—i. e., the head itself. In the diaphysis, as in other long bones, the disease is commonly diffuse. In the epiphysis, on the other hand, it is often localized in a small area of the cancellous tissue. Whereas infections of the shaft and neck of the bone usually run an acute and violent course, with early infection of the joint; such is not the case when a small focus exists within the head only. In this latter group the condition may persist for a long time with the formation usually of a small sequestrum and total or partial absorption of the head. In some cases there are observed small purulent foci in the head, the neck, and the trochanter. Here, as elsewhere, when the disease is extensive, the entire upper end of the femur may undergo necrosis. When the bone is involved close to the epiphyseal line before union has taken place, separation of the head may occur, which may undergo necrosis, or remain as a free body in the joint, or may even survive and become attached in the cotyloid cavity, or to the femur, or both. In some cases the epiphyseal cartilages of the greater and lesser trochanter are involved with separation of the trochanters. In other cases pathological fracture of the neck may be one of the results.

The acetabulum may be primarily or secondarily the seat of osteomyelitis, and here the inflammation may result in perforation of the bottom of the cotyloid cavity, with more or less extensive osteomyelitis and destruction of the bones of the pelvis.

The invasion of the soft parts of the hip-joint, the synovial membrane, the ligamentous structures, etc., may be of an acute, violent, and intensely septic

character, or, on the other hand, here, as in other joints, the inflammation of the bone may be accompanied by a serous, sero-fibrinous, or purulent exudate. In the more severe forms, rapid destruction of all the joint structures takes place. In the subacute cases of osteomyelitis, the changes in the bone lead to deformities of various kinds, sometimes to absorption of the neck, in other cases to a change of direction of the neck in relation to the shaft, a coxa vara. In some cases extensive atrophy of the head and the neck may occur, in other cases the neck is absorbed and the head is enlarged and flattened so that it sits upon the shortened neck close to the trochanter, or embraces the neck like a mushroom. The changes observed in the acetabulum in the less acute cases are rather of a productive than of a destructive character, frequently with the formation of abundant and massive osteophytes, which may cause marked deformity of the bone, and in some cases entirely fill up the cotyloid cavity. The grade of the inflammation of the joint structures varies greatly in different cases, according to the character and severity of the infection. In the slighter cases, a more or less complete fibrous ankylosis may occur with greater or less limitation of motion in the hip-joint. In other cases, somewhat more severe, bony ankylosis results with a subsequent deformity of the pelvis, if, as is the rule, the disease occurs during childhood or youth.

Signs and Symptoms of Osteomyelitis of the Femur Involving the Hip-joint.—Here, as elsewhere described in Vol. I, Acute Osteomyelitis, the disease may be of several types. The patients are usually children or young persons who appear to be enjoying the best of health. In the most acute forms the general symptoms are those of an intense and overwhelming sepsis, sometimes so rapid in its fatal results that the diagnosis of the condition is not made. In other cases, not so acute, the disease is ushered in with high fever, often preceded by chills, disturbances of intelligence, stupor, apathy, or delirium; locally there are the signs of an intense and violent inflammation in the vicinity of the hip. The joint becomes exquisitely tender, the slightest motion causes agonizing pain, and pressure upon the trochanter or upward upon the foot is very painful. The region of the hip-joint rapidly swells, there is total loss of function in the limb. The swelling begins in the upper part of the thigh and gluteal region, and is of a doughy, edematous character, without redness of the skin. Dilated veins may be seen upon the surface and the swelling rapidly progresses, so that soon the thigh as far as the knee, or even lower, may be greatly increased in size. The spontaneous pain is felt in the hip and throughout the entire thigh as far as the knee. If the bones of the pelvis are involved an intrapelvic swelling may be produced, palpable in the iliac fossa.

In a third and less frequent group of cases the disease begins in a subacute form with moderate pain and disability in the hip which gradually increases, and if the infection of the joint cavity occurs slowly by continuity of structure, it may be days or even weeks before serious symptoms are observed. In many cases the disease involves several bones, and other joints may be the seat of swelling. The course of the disease in the most severe cases is toward a rapidly-

fatal termination, with all the symptoms of intense septicemia, as described in Vol. I. In a moderate number of the less severe cases the joint capsule is not perforated, and according as infection of the surrounding soft parts by perforation does or does not occur, the disease may be divided into two groups. In the cases which result in rupture of the capsule, abscesses or diffuse phlegmonous inflammations are formed in either the gluteal region or in the upper portion of the thigh, in front and to the inner side, and these will give the ordinary signs of abscess as they approach the surface. In these cases spontaneous perforation of the skin is often long delayed, for weeks or months if the patient survives, and after spontaneous opening or rupture, sinuses remain leading to carious or necrotic bone, readily detected upon proper examination. In those cases which do not die during the acute stages of the disease the course is exceedingly chronic, the sinuses remaining open for years. Pathological dislocation or, on the other hand, more frequently ankylosis of the hip-joint, results. In the latter group the thigh is ordinarily ankylosed in a position of flexion and may be adducted and rotated inward or flexed, abducted, and rotated outward. Such ankylosis is apt to be firm and often becomes bony. The immobility of the joint is also increased in the earlier stages by the massive infiltration of the surrounding soft parts, tendons, muscles, etc., with inflammatory tissue of new formation. In the cases attended by pathological dislocation, or by absorption and atrophy of the upper end of the bone, very notable shortening of the extremity results. Such shortening is peculiarly marked when the disease causes separation of the epiphysis, and may under such conditions be as great as from two to four inches. In the early stages immediately after the epiphysis has become separated from the bone, there may be abnormal mobility in the joint, succeeded, however, by ankylosis. In the cases resulting in abscess, the patients are exposed to all the dangers of chronic septicemia, progressive anemia, amyloid degeneration of the liver and kidneys, and death from chronic sepsis and exhaustion. In the acute cases death occurs, as already stated, from acute septicemia, sometimes from pyemia. As in other suppurative lesions there is a characteristic leucocytosis in the acute cases. (See this topic in Vols. I and II.)

Diagnosis.—The diagnosis in the ordinary acute cases is usually not difficult from the signs and symptoms already described. The disease may, however, be mistaken for typhoid fever, for acute articular rheumatism, and for some other conditions, described in Vol. I, under Acute Osteomyelitis. Aspiration of the exudate in the joint will determine its character, and cultures its bacterial content.

TUBERCULOSIS OF THE HIP-JOINT, HIP-JOINT DISEASE, TUBERCULOUS COXITIS

Tuberculous disease of the hip-joint may occur at any period of life, but by far the largest number of cases occur between the fifth and the tenth years.

Children of less than two, and young adults of more than twenty are rarely affected. The hip-joint is a very frequent localization for tuberculous infection. In a certain proportion of cases it appears to be the primary lesion of the disease; in many, however, it coexists with tuberculosis of other parts of the body, and in the cases which appear to be primary in the hip it is highly probable that tuberculous foci also exist in the bronchial glands or elsewhere. The predisposing causes of hip-joint tuberculosis are the same as in other localizations—namely, an hereditary predisposition, bad hygienic surroundings, depressed states of health arising from other diseases, the exanthemata, typhoid, etc., and through the existence of other tuberculous lesions. In a certain proportion of cases some slight injury to the hip precedes the outbreak of the disease, and may well constitute a place of diminished resistance for the localization of the tubercle bacilli.

The original focus of disease may occur in the upper epiphysis of the femur —i. e., in the head or in the neck, sometimes in the acetabulum. Primary synovial tuberculosis is believed to be exceedingly rare. A tuberculous embolus having reached the spongy tissue of the bone, an area of tuberculous infiltration occurs which gradually increases in size, undergoes caseation with the formation of a small sequestrum. The surrounding bone is slowly invaded, until the joint surface is approached and finally perforated with an outpouring of tuberculous material into the cavity of the joint. The rupture may occur through the cartilaginous covering of the bones, though more commonly the joint is invaded at the site of attachment of one or other of the ligaments. A miliary tuberculosis is then developed in the synovial membrane. From the borders of the articular cartilages there grows into the interior of the joint a layer of tuberculous granulation tissue (tuberculous pannus). The foci of tuberculosis in the synovial membrane enlarge and undergo softening, with the formation of tuberculous ulcers, which coalesce and destroy the membrane more or less completely. The bone is invaded after the overlying cartilage has been eaten away, and this destruction is progressive, so that the head of the femur and the acetabulum may be extensively softened and destroyed. The destruction of bone is usually more extensive when the primary focus lies in the acetabulum than when in the femur. The ligaments are invaded by tubercle tissue, become thickened and softened; this, together with the bone destruction, may lead to total or partial dislocation upward, with great shortening of the limb. The tissues surrounding the joint are infiltrated with connective tissue of new formation—the protective wall which nature throws out to limit the spread of the disease. Tuberculous abscesses of the soft parts surrounding the joint may originate from rupture of the capsule and invasion of the surrounding tissues, or, what is more common, such abscesses are produced by the breaking down of tuberculous foci outside the joint capsule. Such abscesses may become superficial in the groin, upon the buttock, or upon the outer surface of the thigh and hip. Abscesses may also occur as the result of the perforation of a tuberculous focus of bone outside the joint. If such perforation occurs through the

acetabulum into the interior of the pelvis, an intrapelvic abscess follows which may perforate into any of the surrounding viscera. The condition then becomes far more serious than when such abscesses are superficial.

Symptoms.—The early symptoms of hip-joint disease may come on slowly or suddenly. In the former group it is observed that the child is slightly lame in walking. The lameness is most noticeable in the morning, when pain and stiffness may be complained of. In the latter the early symptoms may resemble those of injury to the hip. The signs and symptoms of hip-joint disease when fairly developed may be grouped under a number of heads.

Pain.—The pain of hip-joint disease is a regular, though not a constant, symptom. It is usually developed early. It is located, as a rule, not in the hip, but in the knee, and is most marked to the inner side, in the distribution of the obturator nerve. The pain is increased by motion and by mechanical shocks to the limb; a blow upward upon the heel, for example. Owing to muscular spasm, these children waken at night and cry out loudly with pain—the so-called "night cries." They are not distinctive of hip-joint disease, but may occur in other conditions as well.

Limitation of Motion.—Limitation of motion in the hip-joint due to muscular spasm is one of the earliest and most constant signs. It is first noticeable as a limitation of complete extension of the hip, and, further, abduction and internal rotation are early limited, as recognized when the limb is flexed to a right angle upon the pelvis and moved in these directions. As the disease progresses the limitation of motion increases, and flexion, at first free, also becomes limited. There may also be spasm of the muscles of the lumbar region when these muscles are put upon the stretch.

Atrophy.—Quite early in the disease the entire extremity, including the muscles and bone, undergo a partial atrophy. The diminished circumference of the limb as compared with the sound side is readily demonstrated with a tape measure. After the disease has existed for some time the atrophy of the bone is demonstrable by the X-rays.

Lameness.—The lameness of hip-joint disease is exhibited chiefly as a lagging of the affected limb. As time goes on and the disease progresses the limp becomes much more marked and is then due to the added flexion, abduction, or adduction of the thigh upon the pelvis, together with inversion or eversion.

Swelling.—The swelling in the early stages of hip-joint disease is not a prominent sign. It may sometimes be detected by palpation of the groin. In the later stages the presence of periarticular swelling, or of abscess, will cause a more or less marked prominence over some portion of the hip. If a tuberculous periostitis or an abscess exists upon the inner wall of the pelvis, it may be palpable per rectum.

Shortening.—Shortening of the extremity in hip-joint disease may depend upon interference with the growth of the femur through malnutrition and disuse, or may be due to actual destruction of the bones entering into the joint. If the head and neck of the femur are destroyed the bone will move upward

upon the ilium. If the upper part of the acetabulum is lost the femur gradually rise upward and bear upon the ilium, forming a grooved trac that bone, along the surface upon which it rests—the so-called "wande acetabulum."

The determination of the amount of shortening is often important in diagnosis and prognosis of the individual case. It is complicated by

FIG. 190.—COXA VARA IN A YOUNG MAN, FOLLOWING TUBERCULOSIS OF THE HIP-JOINT, PA ABSORPTION OF THE NECK OF THE THIGH BONE.

presence of what is known as "apparent shortening," due to the malposi of the affected limb in respect to the pelvis. The malposition may be ei *adduction* or *abduction*. In order that the limb may be brought parallel its fellow the pelvis must be tilted on an antero-posterior axis. If the lim *adducted* that side of the pelvis must be *raised* in order to produce paralle of the extremities. There results an apparent shortening upon the diseased

If, on the other hand, the diseased limb is *abducted,* that side of the pelvis must be *lowered* while the other is *elevated,* thus producing an apparent lengthening of the diseased extremity.

The *real* or bony shortening is measured from the *anterior superior spine* of the ilium to the *inner malleolus,* the two limbs being placed symmetrically in respect to the pelvis. The *apparent* shortening or lengthening, as the case may be, is determined by placing the limbs parallel and measuring from either *malleolus* to the *umbilicus.*

The degree of flexion in which the limb is habitually held by muscular spasm in respect to the pelvis, and the limitation of extension, are roughly measured, first, by observing that the limb is held in a position of flexion, and further, by placing one hand under the lumbar spine while with the other the limb of the affected side is brought down in extension until the ham touches the table. The fixation of the joint in flexion and roughly the degree thereof, may be estimated by the distance to which the lumbar spine rises from the hand; the amount of lordosis, in other words. This will vary with the duration of the disease and the want of, or, on the other hand, the efficiency of the treatment. In advanced cases, if untreated, the femur is markedly flexed upon the pelvis and may be ankylosed in this position so that the lordosis, even when the patient stands erect, is extreme.

The presence of a cold abscess or of a tuberculous sinus in the vicinity of the hip-joint is readily recognized by their typical characters.

The general condition of these children if not properly treated grows steadily worse. They deteriorate in general health and become anemic. A moderate rise of temperature is commonly observed in the evening. If abscesses form and are allowed to rupture, or are incised, and are not properly cared for thereafter, the patient may develop chronic sepsis from mixed infection, with amyloid degeneration of the liver, kidneys, and spleen.

Double Hip-joint Disease.—Double hip-joint disease is occasionally observed. One joint is usually affected before the other.

The Diagnosis of Tuberculous Disease of the Hip-joint.—In examining children for hip disease the patient should be placed naked upon the back, on a firm, smooth surface, preferably a table. The cardinal signs of the disease are muscular spasm, atrophy, swelling, and shortening, with obliteration of the gluteal furrow on the affected side. In addition there are the symptoms of pain and in some cases the presence of tuberculous abscesses. In the differential diagnosis between hip-joint disease and coxa vara the X-rays are of great value. The range of motion at the hip-joint is determined by grasping the leg below the knee with one hand, while the other is placed upon the pelvis. The range of motion in the normal limb should be tested first, flexion, extension, abduction, adduction, and rotation. In manipulating the diseased limb the greatest gentleness should be used not only that the patient may not suffer unnecessary pain, but also that the amount of reflex muscular spasm may be accurately appreciated. It is possible by violent manipulations to underestimate the degree of

spasm, and, moreover, much harm may be done to the diseased joint. Upon the diseased side the limb is slowly and gently flexed. At a certain point the pelvis will be felt to move with the thigh; thus the degree of muscular spasm in flexion is discovered. The Thomas method of estimating the flexion deformity of the limb is useful and is thus carried out. The leg and thigh of the sound side are flexed until the knee touches the chest. If the opposite hip-joint is healthy the ham of that side will remain in contact with the table. If, however, the limb is fixed in abnormal flexion the ham will be raised from the table.

The following method of detecting the amount of flexion deformity present is quoted from Lovett and Nichols, Keen's "Surgery," Vol. II, page 322:

In.	Deg.	In.	Deg.	In.	Deg.	In.	Deg.
0.5	1	6.5	16	12.5	31	18.5	50
1.0	2	7.0	17	13.0	33	19.0	52
1.5	3	7.5	19	13.5	34	19.5	54
2.0	4	8.0	20	14.0	36	20.0	56
2.5	6	8.5	21	14.5	37	20.5	58
3.0	7	9.0	22	15.0	39	21.0	60
3.5	9	9.5	24	15.5	40	21.5	62
4.0	10	10.0	25	16.0	42	22.0	65
4.5	11	10.5	27	16.5	43	22.5	70
5.0	12	11.0	28	17.0	45	23.0	75
5.5	14	11.5	29	17.5	47	23.5	80
6.0	15	12.0	30	18.0	48	24.0	90

The patient lies upon a table flat on his back and the surgeon flexes the diseased leg, raising it by the foot until the lumbar vertebræ touch the table, showing that the pelvis is in the correct position. The leg is then held at that angle, the knee being extended, while the surgeon measures off two feet on the outside of the leg with a tape measure, one end of which is held on the table (so that the tape measure follows the line of the leg) (*a b*); from this point on the leg (*b*), where the measurement of two feet ends, one measures perpendicularly to the table (*b c*), and the number of inches in the line (*b c*) can be read as degrees of flexion of the thigh by consulting Table II. For instance, if the distance between the point on the leg and the table is twelve and a half inches, it represents 31° of flexion deformity of the thigh.

If the leg is so short that it is impracticable to measure off twenty-four inches, one can measure twelve inches; ascertain from here the distance to the surface on which the patient is lying in a perpendicular line in the same way, then doubling this distance and looking at the table as before, the amount of flexion is found.

The method of making measurements for the detection of shortening have already been described, and the atrophy is readily determined by measuring the different portions of the two limbs with a tape.

The method of determining the presence of abduction and adduction is by inspection, since when the patient is placed upon the table with his legs parallel, it is easy to see that one of the anterior iliac spines is above its normal

level, while the other is displaced. The amount of abduction or adduction is estimated in the following way. It is the method of Dr. R. W. Lovett:[1]

The patient lying upon his back with the body as straight as may be, the measurements are taken for the amount of real and of apparent shortening and the results compared. The distance between the anterior iliac spines is then measured.

Turning now to the table, if the line which represents the amount of difference in inches between the real and apparent shortening is followed until it intersects the line which represents the pelvic breadth, the angle of deformity will be found in degrees where they meet. If the apparent shortening is greater than the real shortening, the diseased leg is adducted; if less than the real shortening, it is abducted.[2]

Difference in Inches between Real and Apparent Shortening.	Distance between Anterior Superior Spines in Inches.																	
	1	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13
	¼	5°	4°	4°	3°	3°	2°	2°	2°	2°	2°	2°	2°	2°	1°	1°	1°	1°	1°
	½	10	8	7	6	5	5	4	4	4	4	4	4	4	3	3	3	3	2
	¾	14	12	11	10	8	8	7	7	6	6	5	5	5	4	4	4	3	3
	1	19	17	14	13	11	10	9	9	8	7	7	7	6	6	6	5	5	4
	1¼	25	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6
	1½	30	25	22	19	17	15	14	13	12	12	11	10	10	9	9	8	7	7
	1¾	36	30	26	23	20	18	17	15	14	13	13	12	11	10	10	9	8	8
	2	42	35	30	26	23	21	19	18	16	15	14	14	13	12	12	10	10	9
	2¼	..	40	34	30	26	24	21	20	19	17	16	15	14	14	13	12	11	10
	2½	..	..	39	34	29	27	24	22	21	19	18	17	16	15	14	13	12	11
	2¾	..	..	..	38	32	29	27	25	23	21	20	19	18	17	16	14	13	12
	3	..	..	..	42	35	32	29	27	25	23	22	21	19	18	18	16	14	13
	3¼	..	..	..	..	39	36	32	30	27	26	25	22	21	20	19	17	15	14
	3½	..	..	..	..	..	40	35	33	30	28	26	24	23	22	21	19	17	16
	3¾	..	..	..	..	..	..	38	35	32	30	28	26	25	23	22	20	18	17
	4	..	..	..	..	..	..	42	38	35	32	30	28	26	25	23	21	19	18

In examining a patient for hip-joint disease, the functions of other joints should be studied, notably those of the spine. The child should be made to stoop forward, laterally, to lie down and to get up again and to walk, in order that limitation of motion in the spine or other joints may be discovered, if present. In the early stages of hip disease in a large proportion of the cases the thigh is *flexed, abducted, and everted.* This position will produce *apparent lengthening* on the affected side. It may be persistent, though it usually gives place as the disease progresses to *flexion with adduction and eversion,* or *inversion with apparent shortening.* Such adduction may appear very early in the disease, so that when brought to the surgeon the patient's limb is often found in this position.

[1] R. W. Lovett, *The Boston Medical and Surgical Journal,* March 8, 1888.

[2] Nichols, "Keen's Surgery," vol. ii, p. 323.

The Blood.—In tuberculosis of the hip the blood, as a rule, shows nothing characteristic. The red cells and hemoglobin may be quite normal, or, on the other hand, diminished. Leucocytosis is absent unless an abscess ruptures or is incised with secondary pyogenic infection.

The X-rays in Hip-joint Disease.—In every case of hip-joint disease X-ray pictures of both hips should be taken if possible, and both hips should be taken *upon the same plate.* Several pathological conditions may thus be eliminated. Coxa vara from any cause, separation of the epiphysis, fracture of the neck of the femur, congenital dislocation of the hip, and in elderly persons the diagnosis of arthritis deformans when well developed, is readily made by a good X-ray picture. All these conditions can usually be demonstrated by the X-rays. In the early stages of tuberculosis of the hip the X-rays may, or may not, show anything distinctive. If a considerable focus of softening exists in the head or neck containing a sequestrum, it will show upon the plate. In other cases the shadow of the head or neck will appear less dense near the epiphyseal line, and the distinction between the cortex and cancellous tissue will be sharper as compared with the healthy side. After the femur has become smaller than its fellow from atrophy or delayed growth, the difference in size and density of the two bones is readily apparent. Bone destruction of the head and neck, or acetabulum, as well as dislocation, is readily demonstrated in advanced cases.

Differential Diagnosis.—A number of conditions may simulate tuberculosis of the hip. Many of them may be eliminated by the X-rays as just stated.

Acute Synovitis.—Acute synovitis of the hip from any cause may present all the signs and symptoms of early tuberculosis. In the simple noninfectious forms, or in cases of mild infection, the progress of the case toward recovery under rest and other simple measures will eliminate tuberculosis. In those of an infectious character, notably when due to pyogenic microbes, and especially when secondary to osteomyelitis of the femur, the acute course, constitutional symptoms, leucocytosis, fever, etc., together with the signs of acute inflammation—namely, swelling of the hip, tenderness, acute pain, etc.—will usually enable the surgeon to recognize the probable character of the process. Aspiration of the joint, and microscopic and bacteriological examination of the exudate, are often valuable measures in establishing the exact character of the infection. Gonorrhea should always be thought of and excluded.

Lumbar Pott's Disease.—Flexion fixation of the hip is common when a psoas abscess forms. Usually extension is the only motion limited, rarely all the motions of the hip may be restricted. Fixation of the lumbar spine is readily detected by suitable methods of examination. (See Spine.) The X-ray of the hip will be negative, but will often demonstrate disease of the bodies of the lumbar vertebræ.

Hysterical Joint Affections.—The differentiation from hip-joint disease when an injury has preceded will depend in these cases upon the incomplete and irregular symptom-complex. There will be exaggeration of pain and limp,

while the physical signs do not correspond with hip-joint disease. The presence of hysterical stigmata, etc., greatly aid in the diagnosis. (See Traumatic Hysteria.)

Arthritis Deformans.—Chronic deforming arthritis is a rare affection among children as a monarticular lesion. (See Still's Disease.) The condition may, however, develop in neglected cases of coxa vara, notably those which are due to fracture of the neck of the femur. Tuberculosis of the hip is rare during that period of life when arthritis deformans is most common. The X-rays are a useful aid in the diagnosis. (See also Arthritis Deformans.)

Coxa Vara.—Coxa vara from whatever cause is often mistaken for hip-joint disease. The X-rays will usually give definite information. The characteristic signs of coxa vara are elevation of the trochanter above Nélaton's line, not present in the early stages of hip disease, but only developed in advanced cases, and limitation of motion in abduction; eversion is commonly present. (See also Coxa Vara.)

Congenital Dislocation of the Hip.—In congenital dislocation of the hip all the movements of the joint are free except abduction, which may be more or less limited. Passive movements except in this one direction are also painless. The trochanter is notably elevated above Nélaton's line. The head of the bone can usually be readily palpated upon the ilium and the bone rolls freely under the hand. The axis of rotation is in the direction of the shaft of the femur. The history and the X-rays are positive aids in diagnosis.

Tabetic and paralytic affections of the hip usually have a definite history. Tabetic joints are rare during the period when tuberculosis is common. The paralytic affections usually follow an attack of poliomyelitis in children, and give definite signs and symptoms quite different from tuberculosis. (See Paralytic Dislocation of the Hip.)

Malignant New Growths of the Hip.—Both sarcoma and carcinoma may be mistaken for tuberculous coxitis. Such tumors are apt to occur in later years. If a primary growth exists elsewhere, or there be a history of its removal, the diagnosis will be simple. It is to be borne in mind that women sometimes conceal the presence of a cancer of the breast until a late period of the disease, and that the condition may be discovered only upon the occurrence of a spontaneous fracture, or of a tumor, which may occasionally arise in the vicinity of the hip-joint. If sarcoma is primary in the hip, or a primary carcinoma in some other part is not discovered, diagnostic errors may occur. The new growth will, however, rapidly increase in size and assume characters which are unmistakable, as elsewhere described. A spontaneous dislocation or fracture will occur, there will be a massive swelling of the hip, or, if the tumor be central, there will be dilatation of the bone, and perhaps parchmentlike crackling upon palpation. The subcutaneous veins of the hip will be dilated, areas of softening will develop, hemorrhages into the substance of the tumor, etc. In the early stages the limitation of motion and position maintained may simulate coxitis exactly. The X-ray may show bony destruction or dilatation

quite different from coxitis. An exploratory incision will, as a last reso establish the diagnosis.

ARTHRITIS DEFORMANS OF THE HIP

Arthritis deformans of the hip, sometimes known as malum coxæ seni osteo-arthritis of the hip-joint, the formative type of chronic arthritis of the hi The lesions of this disease are sufficiently described in Chapter VIII of th volume. Here may be added that this type of chronic arthritis is freque both as a solitary lesion affecting the hip, and also associated with chro arthritis of other joints. The head of the bone may be changed in shape or eroded as to be nearly or quite destroyed. Coxa vara may develop as a p of the lesion from the change in the angle between the shaft and the ne The neck may undergo absorption. The head may be widened and flattened a sit closely upon the shaft. There is often a large production of new bone and around the acetabulum, so that its shape is changed and its cavity nea or quite obliterated. As the result of pressure, absorption of the upper port of the rim of the acetabulum may occur, so that the head gradually trav upward, forming a new articular bearing upon the ilium, another type of "wandering acetabulum." In most of the cases, though, the femur and acetabulum are changed in size and form and their relations cease to be normal; nevertheless, the bones preserve some semblance of an articulation and fit together, more or less imperfectly, so that the functions of the joint, though modified and restricted, are still to some extent preserved. In time, however, there is a gradual increase of stiffness and limitation of motion in the joint in all directions; only rarely, however, does complete ankylosis, fibrous or bony, occur.

The disease is more common in men than in women, and occurs usually after the fortieth year of life. In the majority of instances it is developed spontaneously. The patients are frequently robust, and appear to be otherwise in good health. The disease appears to bear no relation to gout nor to ordinary acute polyarticular rheumatism. The onset is usually insidious, though in some cases it begins acutely and may resemble an attack of acute rheumatism. In the latter group the acute symptoms subside and the course of the disease becomes chronic, sometimes with remissions and exacerbations of the symptoms. In the typical cases, however, the course is slowly and steadily progressive from the start. The first symptoms noticed are a sense of fatigue and weakness in the limb, soon accompanied by pain referred usually to the course of the sciatic nerve. The pain and stiffness are most marked when the patient arises in the morning, and are also observed after he has been sitting quietly for some time and rises to a standing posture. After the patient has moved about and used his limb for a time the symptoms diminish or even disappear. As time goes on the pain and stiffness of the hip grow slowly worse, so that the patient limps and spares the limb as much as possible.

Gradually marked limitation of motion develops, so that upon making a sudden and extensive movement of the limb severe sharp pain is felt.

While in young persons arthritis deformans runs a fairly rapid course, so that very marked gross pathological changes may occur at the end of a year or two, in the elderly the disease progresses slowly, so that it may be many years before gross pathological changes occur in the joint structures, recognizable on inspection and palpation. In well-developed cases the entire limb undergoes a progressive muscular atrophy, largely from want of use, which is visible upon inspection and demonstrable upon measurement. The trochanter rises above Nélaton's line, and the spine of the ilium on the affected side is higher than upon the other. That is to say, the diseased limb is adducted. It is at the same time everted. There is apparent, as well as real, shortening. When viewed from in front or behind the affected hip appears more prominent than its fellow. On palpation, bony thickening of the trochanter is felt. In the outer half of Scarpa's triangle in front, a bony resistance of variable size and shape can usually be appreciated upon palpation. Upon testing the mobility of the joint the normal excursions are usually limited in all directions. This will be especially true of abduction, though rotation in either direction is also restricted and painful. The motions of the joint are not smooth. Creaking and even bony grating are usually felt and heard as the eroded and roughened bones move one upon the other. Such signs and sensations may be appreciated by the patient himself during the use of the limb. The X-rays will demonstrate the bony deformities and displacements clearly.

As time goes on the pain and diminution of function increase, there is spontaneous pain in the hip, knee, and thigh which may be so severe as to interfere with sleep. The use of a crutch becomes necessary for locomotion. At a later period the limb may become entirely useless from atrophy and shortening, so that if the patient gets about at all it must be with a pair of crutches. In some cases the pain on motion is so severe that the patient may become bedridden or confined to an invalid wheel chair.

Diagnosis.—Arthritis deformans of the hip must be differentiated from tuberculosis. See that topic in Volume I and in the preceding paragraphs of this chapter. In its early stages it is more apt to be confounded with sciatica than with any other disease, since, as mentioned, the pain is often referred to the course of the sciatic nerve rather than to the hip itself. In sciatica all the movements of the hip-joint are free except flexion when the knee-joint is extended. This movement puts the sciatic nerve upon the stretch and is, therefore, painful. In arthritis deformans there is *early in the disease a distinct limitation of abduction.* This is easily recognizable by having the patient remove his clothing and asking him to straddle widely. It will then be seen that abduction is distinctly limited upon the affected side, and that in separating his legs the motion takes place largely at the healthy hip-joint.

From other conditions, the age of the patient, the spontaneous occurrence,

the X-rays, the very chronic course, the absence of fever and of the signs of acute inflammation and suppuration—all serve to give the disease a fairly definite character. Tumors of the spine and tumors of the cord must be eliminated by a consideration of the data given under these topics. Tabes and syringomyelia are to be excluded by a careful consideration of the history and of the absence of the characteristic signs and symptoms of these conditions.

Prognosis.—Cure does not occur in chronic arthritis deformans, the tendency of the disease being toward slow but sometimes intermittent progression. By suitable medication, bathing, baking, and the use of a protecting and supporting apparatus, the progress of the disease may be delayed and the patient made more comfortable.

COXA VARA

By the name coxa vara we designate a condition in which, from one cause or another, the angle between the neck and the shaft of the femur is changed, so that instead of being from 120° to 140° roughly, as is normal, it is diminished to a right angle, or even less, and as a consequence there are produced more or less marked disturbances of function in the hip-joint, limitation of motion, pain, and other symptoms. The condition may arise in a number of ways, from injury, from rachitis, and in the course of a number of diseases of the hip-joint, tuberculosis, arthritis deformans, osteomyelitis of the femur, etc. In the conditions associated with destructive diseases of the hip-joint, such as tuberculosis, osteomyelitis, and arthritis deformans, the mere presence of coxa vara forms only an unimportant part of the lesion, and as such may give rise to symptoms which are completely overshadowed by the more serious manifestations of the destructive disease. As a pathological entity the traumatic cases are much the most important. The rachitic cases also are of interest.

Symptoms.—The patient complains of a sense of weakness in the hip-joint, develops a limp, and finds that after exercise or fatigue the joint becomes distinctly painful and irritated. Owing to the changed relations of the neck and shaft, the trochanter rises above Nélaton's line, the limb is adducted and abduction is distinctly limited, but the patients are not conscious of the true condition; they merely have a feeling as though one leg were shorter than the other. There is a compensatory lateral curvature of the spine. Upon examining the patient, as described under Fracture of the Neck of the Femur and Tuberculosis of the Hip-joint, it will be observed that the trochanter rises above Nélaton's line, that both apparent and measured shortening are present, that the limb is adducted, that abduction is distinctly limited and painful. If the joint is in a condition of acute irritation all motions may be restricted, and the only certain means of differentiation between coxa vara and tuberculosis of the hip-joint in these cases will be by means of the X-rays, or by rest of the joint and time. In addition to upward displacement, the trochanter is found displaced a little backward. There is slight outward rotation of the limb.

Owing to the changed mechanical relations, if the leg is held everted and the attempt is made further to flex the hip, the motion will occur rather in the direction of abduction than of flexion. In cases due to *rachitis* and to congenital or acquired softening of the bones, coxa vara is *frequently bilateral.* In these there will be no difference in the length of the limbs; there will, however, be marked adduction, which may be so extensive that the patient can only walk cross-legged. The trochanters will appear unduly prominent.

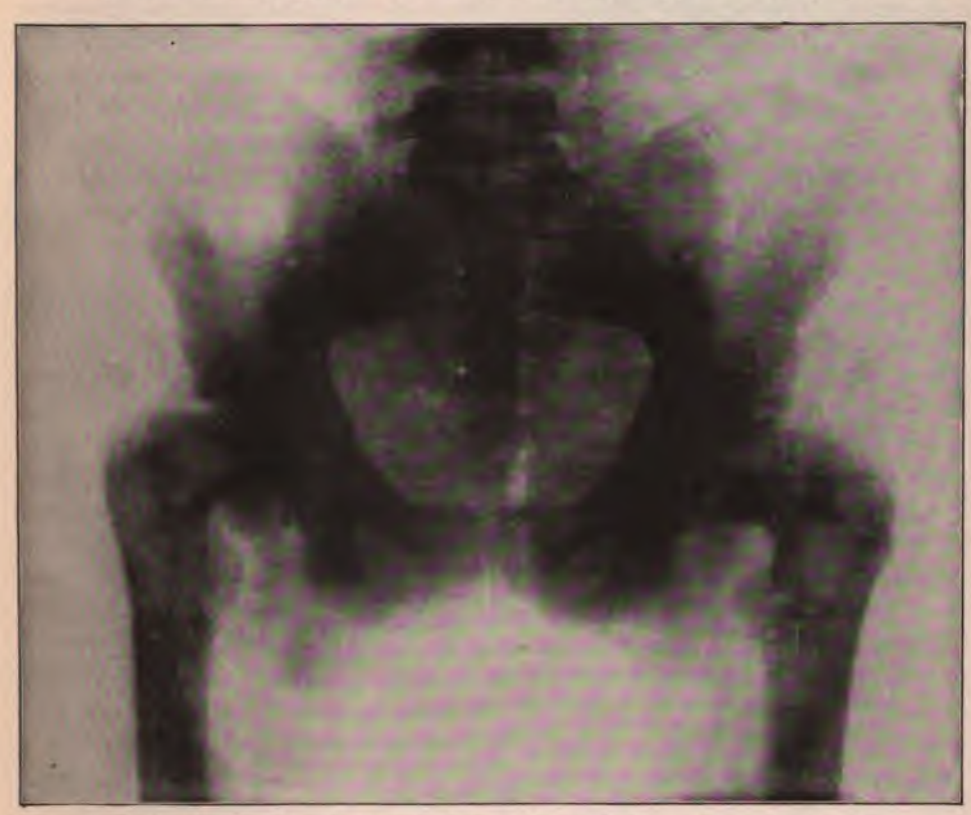

FIG. 191.—DOUBLE COXA VARA IN A YOUNG MAN. Rachitic. X-ray by the author.

In the bilateral cases scoliosis will be absent. In the *traumatic* cases in children there will be a history of an injury to the hip; the actual lesion will be a separation of the epiphysis or a fracture of the neck. The child will suffer from pain and more or less marked disability in the hip-joint, and, according to the extent of the fracture and the degree of displacement, the symptoms and signs of coxa vara may come on at once, or be delayed for months, or even a year or more. Seldom, however, do these children completely regain the perfect functional use of the hip. Some pain and stiffness remains behind which gradually grows worse as time goes on. In a good many cases, notably those in which the hip-joint is distinctly irritated by use, the differential diagnosis from tuberculosis can be made only by means of the X-rays. It may be

observed, however, that the distinctive signs of coxa vara are elevation of the trochanter and limitation of abduction, whereas in tuberculosis, elevation of the trochanter is not observed until the disease is far advanced and, as elsewhere stated, all motions are restricted. Coxa vara must also be distinguished from congenital dislocation of the hip. In both these conditions the trochanter is above Nélaton's line, and in both abduction is limited. In both, also, from overuse of the joint, all motions may be painful and restricted. The examination of congenital dislocation will show the head upon the dorsum of the ilium, as a rule, with the characteristic mobility of the femur around its own long axis. In coxa vara the head of the bone is in the acetabulum; in congenital dislocation it is not.

Prognosis.—Coxa vara does not get well spontaneously.

Treatment.—In the early traumatic cases strong abduction of the limb under an anesthetic may more or less completely restore the neck and shaft to their normal relations. In cases of separation of the epiphysis, if the change in the angle of the neck and shaft is not too marked, Whitman's operation, as described under Fractures of the Neck of the Femur in Children, may be used with advantage. In other cases the best operation is a subtrochanteric osteotomy, either cuneiform or linear, with correction of the deformity by putting up the entire limb and pelvis in a position of abduction and internal rotation. Such a dressing must be worn for at least two months, after which a suitable supporting splint must be applied and worn for a number of months longer. In choosing the time for operation it is best to wait until all active irritation of the joint has subsided, as the result of rest.

THE DISEASES OF THE BURSÆ OF THE HIP

A large number of synovial bursæ are found in the vicinity of the hip-joint. From fourteen to twenty-one have been described by various writers. Two of them are, however, much more important from a surgical point of view than the others, and especial attention will be given here only to these two. The most important bursa is the so-called *bursa iliaca*. This bursa is of considerable size. In the adult it may be two inches long and an inch and a half wide. It lies beneath the ilio-psoas muscle between it and the pubis, and is situated below and a little to the outer side of the pectineal eminence. As elsewhere stated, this bursa is in close contact with the capsule of the hip-joint and is not far removed from the anterior crural nerve.

In about ten per cent of the cases in adults the bursa communicates with the hip-joint. In infectious processes of the bursa the hip-joint may be secondarily involved. The bursa itself may become infected by the extension of a suppurative or other infectious process from above, along the course of the psoas iliac muscle, and then secondarily involve the hip-joint.

The other important bursa is the so-called *gluteal bursa*, or bursa beneath the tendon of the gluteus maximus. The bursa lies between the gluteus maxi-

mus and the great trochanter, where the tendon of the muscle passes across the surface of the bone. It is a bursa of considerable size, and when inflamed may become very large indeed.

Other bursæ of less importance are a subcutaneous bursa over the large trochanter, a bursa beneath the tendon of the gluteus medius, separating it from the upper portion of the outer surface of the great trochanter, a bursa which lies upon the inner surface of the top of the great trochanter between it and the tendon of the gluteus minimus. The other bursæ are of less consequence from a pathological point of view. There is sometimes one situated between the gluteus maximus and the tuberosity of the ischium.

Here, as in other situations, these bursæ may become inflamed as the result of simple trauma, or as the result of infection with pyogenic microbes, either brought to the bursa from without as the result of an open wound, or in the course of infectious diseases, pyemia, septicemia, the exanthemata, typhoid fever, gonorrhea, etc.; there may be a localized hematogenous infection of one or other of these bursæ, which may be of any possible degree of intensity from an inflammation attended by a serous exudate to an inflammation which causes an intense septic inflammation of the bursa itself and may spread into the surrounding tissues with disastrous results. The inflammations and infections of the iliac bursa are, as already indicated, of greater consequence by reason of its proximity to the hip-joint.

In a considerable proportion of the cases of simple inflammation of these bursæ, a *hygroma* of the bursa is produced with the formation of a tense, elastic swelling, of smooth surface and rounded, ovoid outline, containing serous fluid. If the inflammation is the result of a contusion, such fluid may be blood-stained or bloody. The superficial bursa overlying the great trochanter, being exposed to mechanical insults, not infrequently becomes inflamed. From its superficial situation and the presence of ordinary signs of acute or chronic inflammation, the diagnosis is usually quite simple or may be made easily with an aspirating syringe or by incision, if such seems necessary.

Inflammations of the Iliac Bursa.—Inflammations of the iliac bursa are characterized by the presence of pain and swelling in the upper and outer part of Scarpa's triangle. The tumor formed may reach a very considerable size, as large as a man's fist, for example. According to the character of the infection, the symptoms will vary as in inflammatory foci in other parts. In some cases a sort of double sac is formed lying on either side of the iliacus tendon, and it may be possible to press the fluid contained in the bursa from one sac to another and to recognize the condition from this sign. If the inflammation is noninfectious, a simple hygroma in fact, it will not necessarily be tender nor painful, will usually fluctuate, the surface will be smooth and the skin movable over the tumor. In some of the cases, if the bursa reaches a large size, it may produce symptoms of irritation in the branches of the anterior crural or obturator nerves, pain on the inner surface of the thigh and knee, etc. If the bursa is large, and more especially if it becomes acutely inflamed, the patient

will hold the thigh in a position which may strongly suggest hip-joint disease. The limb will be moderately flexed and usually abducted and rotated outward; in rare cases flexed, adducted, and rotated inward. The disease may thus be readily mistaken for tuberculous coxitis, and this will more especially be the case if the bursa has suppurated and has left a sinus behind. The most important differential point between an iliac bursitis and tuberculosis of the hip is that in the former condition the patient may often walk and bear weight upon the limb without discomfort, whereas in tuberculosis standing and walking cause pain. Another important point to bear in mind is that in bursitis the relation of the trochanter to Nélaton's line is normal. Moreover, measurements properly taken will show no difference in the lengths of the two extremities, and thereby we are able at once to eliminate a number of conditions affecting the hip-joint.

Inflammation of the Deep Gluteal Bursa.—Inflammations of the deep trochanteric bursa cause a swelling of the outer side of the hip over and above the great trochanter. The tumor may reach a considerable size and spread backward to such an extent as wholly or partly to obliterate the gluteal furrow. In these cases also the limb assumes a position not unlike that observed in hip-joint disease, but here again the individual is able to stand up without pain. Neither does crowding the lower extremity upward, as from a blow upon the heel, cause discomfort. When the bursæ become the seat of suppuration the course of the condition is that of localized suppuration within a superficial cystlike cavity, or if the bursa is perforated, a diffuse suppurative process, or even a cellulitis of the phlegmonous or gangrenous type, may occur, as in other situations. (See Diseases of Wounds, Vol. I.) When disease of the iliac bursa invades the hip-joint the symptoms produced will vary according to the character of the infection, whether pyogenic or tuberculous, as elsewhere described.

The treatment of these conditions is incision with destruction of the lining of the sac with pure carbolic acid, or in the more superficially placed bursa excision if it be found necessary. In the iliac bursa one should be very careful about injecting irritating or caustic fluids, less perchance the bursa communicate with the hip-joint. The treatment of the various forms of bursitis will also vary to some extent with the character of the infection.

DISEASES OF THE LYMPH NODES OF THE GROIN

The lymph nodes of the groin carry the lymph from the entire lower extremity, partly from the external genitals and from the perineum, the region of the anus, gluteal region, and lower part of the abdominal wall.

The lymphatic glands of the lower extremity are divided into a superficial and a deep set. The superficial set are found in the groin. The superficial inguinal glands lie immediately beneath the skin, are of considerable size and number from eight to ten. They may be divided into two groups, the first

lying in general along the course of Poupart's ligament. They receive the lymph current from the integument of the lower portion of the abdominal wall, the scrotum, the penis, the perineum and region of the buttock, as well as from the mucous membrane of the urethra. The second or lower group are arranged about the saphenous opening in the fascia lata. A few glands are found below this, or arranged along the course of the saphenous vein. This lower group receive the lymph from the superficial portions of the lower extremity.

The *deep lymphatic glands* of the lower extremity are the anterior tibial, popliteal, deep inguinal, gluteal, and ischiatic. (Anatomical details of this section are adapted from Gray's "Anatomy.") The anterior tibial gland, not constant, is found when present upon the interosseous membrane at the upper part of the leg alongside the anterior tibial artery. It is scarcely of surgical interest.

The deep popliteal glands are of small size. They surround the popliteal vessels in the popliteal space. They are four or five in number.

The deep inguinal glands lie beneath the deep fascia around the femoral artery and vein. They communicate through the saphenous opening with the superficial inguinal lymph nodes.

The gluteal and ischiatic glands are placed, the former above, the latter below, the pyriformis muscle resting on their corresponding vessels as they pass through the great sacro-sciatic foramen.

The *superficial lymph channels of the lower extremity* lie beneath the skin, and are divisible into an internal and external group following the course of the internal and external saphenous veins, respectively.

The internal group, the larger, begin on the inner side and dorsum of the foot. They pass, some in front, some behind the inner ankle, run up the leg with the internal saphenous vein, pass with it behind the internal condyle of the femur, and accompany it to the groin, where they terminate in the group of inguinal glands which surround the saphenous opening. Some of the efferent vessels from these glands pierce the cribriform fascia and sheath of the femoral vessels and terminate in the lymphatic gland contained in the femoral canal, thus establishing a communication between the lymphatics of the lower extremity and those of the trunk; others pierce the fascia lata and join the deep inguinal glands.

The external group arise from the outer side of the foot, ascend in front of the leg, and, just below the knee, cross the tibia from without inward, to join the lymphatics on the inner side of the thigh. Others commence on the outer side of the foot, pass behind the outer malleolus and accompany the external saphenous vein along the back of the leg where they enter the external popliteal glands.

The *deep lymphatics of the lower extremity* are few in number and accompany the deep blood-vessels. In the leg they consist of three sets. The anterior tibial, peroneal, and posterior tibial which accompany the corresponding blood-vessels, two or three to each artery; they ascend with the blood-vessels and enter the lymphatic glands in the popliteal space; the efferent vessels from these glands accompany the

femoral vein and join the deep inguinal glands; from these the vessels pass beneath Poupart's ligament and communicate with the chain of glands surrounding the external iliac vessels.

The deep lymphatics of the gluteal and ischiatic regions follow the course of the blood-vessels to the great sacro-sciatic foramen.

It should be borne in mind that when malignant growths exist of the lower extremity, or of any of the regions drained by the above-mentioned glands, in addition to palpation of the superficial lymphatics of the groin the surgeon should also seek to discover if the iliac and lumbar glands within the pelvis are also enlarged, since the question of operability in the given case will often be determined by these findings.

The lymphatic glands of the groin become enlarged under a great variety of pathological conditions affecting the lower extremity. In affections of the scrotum, penis, skin of the lower portion of the abdominal wall and of the perineum, anus and gluteal regions, the upper group—namely, those along the course of Poupart's ligament—are first involved. Among the commonest causes of enlargement of these glands are the venereal diseases affecting the external genitals, syphilis, and chancroid. As was pointed out under syphilis, certain diagnostic data relating to the lymph nodes are of interest and value in this connection. The lymphatic enlargements or buboes accompanying the initial lesion of *syphilis* are firm, painless, and discrete. It is to be borne in mind that chancre on one side of the median line may be, and often is, accompanied by enlargement of the lymph nodes in both groins, although the individual glands are frequently larger upon the side of the lesion than upon the other. It usually happens that one gland, perhaps that which first receives the infection, is larger than the rest and is surrounded by a group of smaller enlarged glands. This arrangement was termed by Ricord a pleiad. The syphilitic adenitis is rarely of great size in the groin, presenting a contrast to the very large lymphatic buboes observed in the submaxillary region when the infection is upon the lip or tongue. In the groin the separate nodules are rarely larger than a cherry and may not be larger than a pea. The glands remain non-adherent to the surrounding tissues. The consistence of syphilitic buboes—i. e., their stony hardness—affords diagnostic aid in most cases. The fact that they persist for weeks or months after the initial lesion has healed is also characteristic of the disease. A mixed infection with pyogenic microbes may obscure the picture at once, the glands then presenting the ordinary type of acute pyogenic infection with pain, periadenitis, adhesion to the skin, and occasionally suppuration.

The adenitis of *chancroid* is not absolutely constant. A bubo occurs in about one case in three. The adenitis may be bilateral. The infection may follow one of several courses. The glands become enlarged, tender, and painful, but may after days or weeks go on to resolution. In another group of cases the infection extends beyond the glandular capsule, and the periadenitis thus pro-

duced causes an agglutination of the entire group of glands, so that a hard, tender, painful, red mass occupies the groin, which may increase to the size of a closed fist. Upon incision the separate glands will be found in different stages of suppuration, or necrotic inflammation, some of them entirely destroyed, being represented merely by an abscess cavity, others containing purulent foci, scattered here and there in the glandular substance, and still others merely in a state of intense inflammatory congestion. If incision is still further delayed, the picture simply is that of a large abscess cavity crossed by cords and trabeculæ of necrotic tissue and surrounded by a dense inflammatory mass of infiltration. After incision the abscess may heal in the ordinary way. It is to be borne in mind that *the more virulent types of chancroid* may be followed by a bubo, which, if it be incised or allowed to burst, takes on the typical characters of chancroid and continues indefinitely, as a slowly or rapidly progressive ulcerative process, unless treated by heroic measures. I have seen cases of this kind which had remained open for years. It is also to be borne in mind in the diagnosis of chancroidal bubo, that we cannot, from the appearance of the sore or the following adenitis, exclude the presence of *syphilitic infection.*

The adenitis of the groin following wounds and infectious processes of the skin and subcutaneous tissues of the foot and leg involves first the lower chain of lymphatics surrounding the saphenous opening. Such infection may occur from a great variety of conditions. Often some trifling scratch or abrasion of the toe, foot or leg is followed by lymphangitis, evident from the red streaks running up the limb to the groin and by enlargement of the lower group of lymph nodes. The course of the disease may be more or less severe, according to the character of the infection and the resistance of the individual. In the average case, rest, elevation of the limb, wet dressings, and cold, in the form of an ice bag, will frequently cause a rapid resolution of the inflamed glands and recovery. In other cases the glands may go on to the formation of an abscess, and in still others to dangerous or even fatal systemic infection. As elsewhere stated in this book, I have seen several instances of chancroidal infection of the inguinal lymph nodes end in fatal septicemia, or in septic pneumonia. In the presence of an acute inflammatory enlargement of the lymph nodes of the groin, it is the duty of the surgeon to find the source and character of the infection. Unless care be exercised, this may be missed. The irritation produced by scratching the region of the anus in cases of pruritus ani may produce an inguinal bubo. I have seen a large suppurative bubo occur from scratching, in a case of pediculi of the pubes. Where no source of external irritation seems to be present, one should think of a possible malignant growth, or of the presence of tuberculosis. The lymph nodes of the groin are an occasional seat of tumor formation in pseudo-leukemia or Hodgkin's disease. The presence of multiple lymphatic enlargements in other regions is usually sufficient for the diagnosis. (See also Hodgkin's Disease.)

It is to be borne in mind that the removal of the lymph nodes of both groins

may be followed by chronic edema and inflammatory thickening of the legs well as of the scrotum and penis, which may or may not be recovered fr and will cause the patient much discomfort and uneasiness. Obstruction of lymph nodes of the groin by filariasis has been discussed elsewhere. (S Scrotum and Penis, Vol. II.)

Tuberculosis of the lymph nodes of the groin is not a very rare localizati The tuberculous infection may follow a wound of an ulcer of the leg or fo Charles N. Dowd reported nine cases which had come under his observati in children. The infection followed apparently improperly treated woun of the foot in all but two cases. The children were dwellers in teneme houses, and were accustomed to go barefoot. The femoral lymph nodes w those first affected in nearly all cases, although in one instance the poplit glands were also enlarged. Subsequently the inguinal lymph nodes along t course of Poupart's ligament were invaded. The appearance of the glandu involvement was delayed from several weeks to several months after the rece of the wound. In one instance the ulcer of the foot was excised and was fou to contain tuberculous tissue. In some of the cases tuberculosis in other org followed. I have seen a number of cases of tuberculous infection of the femo and inguinal glands, but in none of them could a history of the original fo of infection be obtained. I recall numerous cases seen in the hospitals amc children, and one upon which I operated in 1908, an elderly man, a member the police force, not only the femoral and inguinal nodes but also the il glands were involved. In none of these cases, however, was the patient a to recall any wound or ulcer of the foot or leg, though the policeman had chronic eczema of the leg through which the infection probably took place. have seen one case which followed gonorrhea, and which ended in a fatal tub culosis of the lungs in less than a year. The diagnosis of tuberculous infect of the lymph nodes is usually not very difficult. There is a history of a sl and painless enlargement of the lymphatic glands, and here, as elsewhere, disease passes through a regular course of softening, periadenitis, the format of a cold abscess and of sinuses. In some cases the diagnosis is not suspec until the time of operation.

CHAPTER XIX

INJURIES OF THE THIGH

INJURIES OF THE BLOOD-VESSELS OF THE THIGH

Owing to their superficial and exposed position, the femoral artery and vein below Poupart's ligament in the upper third of the thigh are not infrequently injured by external violence. The injuries may occur from incised, stab, contused, and lacerated or gunshot wounds. The wound may involve the artery alone, or any of its branches, or the vein alone, or both artery and vein. A wound which completely divides the common femoral, or the superficial femoral in Scarpa's triangle, is not likely to come under the care of a surgeon. Death takes place from hemorrhage in a very short time. If the artery be only partly divided, or merely punctured, the subsequent history will depend upon the size of the wound in the vessel, and to some extent also upon the size of the wound in the skin. If the wound in the vessel be large, again the patient will rapidly bleed to death. The diagnosis of the condition presents no difficulties. Bright arterial blood spurts forth in a powerful stream with a force which varies with the heart beat. In a vessel of this size which is freely open, the escaping blood makes a hissing sound. The smaller the wound the less the force of the stream of blood, and the smaller its size. In some cases if the opening be very small it may be blocked by a clot, though consecutive hemorrhage is very apt to occur as the result of movements on the part of the patient, or the use of the limb. In other cases if the wound in the skin be small, there is formed an arterial hematoma in the thigh which will rapidly increase in size, causing great swelling of the limb, interference with the circulation, and the signs given in Vol. I, under Arterial Hematoma, or Primary Traumatic Aneurism. Expansile pulsation is not observed, but the ear or the stethoscope applied over the region of the wound will permit the examiner to hear a systolic blowing murmur. The presence or absence of an arterial pulsation in the vessels of the foot is not a sign of absolute diagnostic significance. If the artery is only partly divided, there may still remain a pulsation in the vessels below. If, however, the pulse be compared on the two sides of the body and be found less full in the wounded limb, it is highly probable that the artery is injured. If no pulse at all be felt upon the injured side the pulse in the opposite extremity should be felt for, since, if the patient has lost a great quantity of blood, the arterial tension may be so low that the pulse upon the injured side will be unappreciable.

Wounds of the femoral vein are characterized, if the vessel be largely or wholly divided and the wound in the skin of considerable size, by the rapid escape of dark venous blood, not in jets but as a steady stream. If, however, the patient makes a strong expiratory effort, the blood may for the moment spurt with considerable force. Wounds of the branches of the femoral vein, even so large a branch as the internal saphenous, are rarely of great gravity. The bleeding may, as a rule, be stopped by gentle pressure.

FIG. 192.—MAN, AGED THIRTY-THREE, ADMITTED TO THE SERVICE OF DR. CHARLES MCBURNEY IN BELLEVUE, MAY 30, 1881. Rupture of the adductor longus muscle due to contusion at the upper part of the thigh. (Collection of Dr. Charles McBurney.)

In the course of operations for *hernia* the femoral vein, and also occasionally the femoral artery, may be punctured by the needle. The recognition of either condition is usually quite simple, as the needle passes through the vessel and the suture is drawn upon there occurs a sudden flow of bright or dark-colored blood, according to whether the artery or the vein is wounded. The accident has been in some cases a very serious one, and has necessitated the ligation of either the artery or the vein, and has in a few cases ended in gangrene of the extremity. If the accident happens, every effort should be made to apply a lateral suture to the wall of the injured vessel. The gravity of an injury to the vein is far less than that of injury to the artery. The vein may be ligated, so long as the operation be done in an entirely aseptic manner, without any risk of interference with the circulation. Ligation of the artery, on the other hand, is a fairly serious matter, and is followed by gangrene of a greater or less portion of the extremity when done for injury in about one case in twelve. The simultaneous ligation of both artery and vein is a very serious procedure indeed, and is followed by gangrene of the extremity in cases of injury in nearly forty per cent. The conditions will, of course, be modified in different cases by the amount of pressure upon surrounding vessels by the effused blood, the extent of contusion and laceration of these vessels which normally would form

a collateral circulation, and by the age and condition of the patient, the presence or absence of arteriosclerosis, for example. Gunshot wounds of the upper portion of the thigh may be followed by immediate death from hemorrhage, or by the formation of a traumatic aneurism, according to the extent of the injury to the artery. Here, as elsewhere, the bullet itself, or a fragment thereof, or a splinter of fractured bone, may produce the injury to the vessel.

INJURIES OF THE MUSCLES OF THE THIGH

Injuries of the muscles of the thigh as the result of open wounds are usually open to inspection, or may be readily recognized during the necessary procedures for the disinfection and closure of the wound. If the external wound be small the division of a muscular belly may usually be recognized by the depression which exists at the point of severance, and by the tumor formed by the contraction of a muscular belly upon the proximal side of the wound.

Fig. 192*a*.—Another View of Fig. 192.

The subcutaneous ruptures of the muscles of the thigh are of somewhat greater diagnostic interest. They occur as the result of violent muscular effort when the individual tries to save himself from falling, or some similar act, or by a blow upon the muscle when it is in a state of contraction. A case of this kind occurred in the service of Dr. Charles McBurney in Bellevue Hospital in 1881: a rupture of the adductor longus caused by a contusion of the upper and inner portion of the thigh when the adductor muscles were tense. It is figured in the text. (See Fig. 192.) One or other of the adductors may be partly ruptured by the efforts made by a rider to stay in the saddle upon a shying or bucking horse. Cases have also been observed of rupture of the iliopsoas muscle as the result of violent lifting efforts, during tetanic convulsions and during labor. The ham-string muscles may also be ruptured as the result of sudden muscular effort. Much more frequently than any of these accidents

FIG. 193.—RUPTURE OF THE QUADRICEPS EXTENSOR CRURIS TENDON. (New York Hospital collection.)

FIG. 194.—EXTENSIVE BONY DEPOSIT IN THE MUSCLES ATTACHED TO THE UPPER PORTION OF THE FEMUR. Fracture of such a bony mass would certainly test the diagnostic skill of any surgeon. (Anatomical Department of the College of Physicians and Surgeons, Columbia University.)

is rupture of the extensors of the thigh, the quadriceps extensor cruris. The rupture may involve the rectus femoris or may extend laterally into the vasti. In the case of the rectus, if its muscular belly be ruptured a very distinct hiatus will be felt on the front of the thigh, and the movement of extension of the knee will cause the formation of a tumor in the upper part of the thigh as the muscular belly contracts. More frequent than rupture of the muscular bellies is rupture of the quadriceps extensor tendon above the knee. A case of this kind is shown in the text. The diagnosis is easy. The power of extending the limb is greatly diminished or lost. A distinct hiatus exists above the patella into which the entire hand sinks with ease.

Hernia of the Muscular Bellies of the Thigh.—Rupture of the fascia covering the muscles of the thigh may result in a hernia of one or other of the muscular bellies. It may occur from direct external violence, or from within as the result of the penetration of the muscle and its fascia by a sharp, bony fragment of the femur, or apparently from a

mere muscular contraction. In the thigh, these muscle herniæ are produced more often by efforts of an unskillful rider to remain in the saddle than from any other cause, and the tear in the fascia may be combined with a greater or less rupture of the muscle itself.

The symptoms are, during a violent muscular effort, the occurrence of a sudden sharp pain in the thigh, with muscular weakness, followed by swelling, tenderness, and ecchymosis. The signs and methods of recognition of these herniæ have been described under Injuries of the Muscles of the Upper Extremity. If the tear in the fascia is of considerable size, and if there results a marked hernial protrusion of the muscle, causing continuous pain, disability, etc., the proper method of treatment is to expose the injured muscle by an incision, to suture its ruptured portion, and to close the fascia over it, if necessary, undermining the fascial layer on either side in order to relieve tension.

INJURIES OF THE NERVES OF THE LOWER EXTREMITY

Injuries of the nerves of the lower extremity are rare as compared with those of the arm. The nerve most frequently injured is the external popliteal.

The Anterior Crural Nerve.—Although its position is rather superficial, the anterior crural nerve is not often injured. The conditions under which such injuries have been reported are open wounds—either stab, incised, or gunshot—of the upper portion of the thigh, operations upon the thigh in Scarpa's triangle, and occasionally as the result of the somewhat violent manipulations used in the treatment of congenital dislocation of the hip-joint. In treating this dislocation subcutaneously, it is necessary to stretch, and even to rupture, portions of the adductor muscles in the groin; and the surgeon, putting the adductors upon the stretch, uses a very considerable amount of force, sometimes combined with a chopping movement upon the tense muscles. In this way the anterior crural nerve may be injured, although the reported cases are few.

The principal function of the anterior crural nerve is the muscular supply of the quadriceps extensor. The other muscles to which it sends branches—sartorius, pectineus, and psoas-iliacus—it supplies only in part, so that the chief symptom produced is paralysis of the quadriceps. This causes inability to flex the thigh upon the pelvis and to extend the knee. The diagnosis of the injury is therefore simple. The injury produces a peculiar gait; the patient drags the limb and brings it forward by contraction of the adductor muscles. The patellar reflex is lost. There is loss of cutaneous sensation over an area which covers a portion of the inner aspect of the ankle as far down as the border of the sole and extends upward nearly to the middle of the inner aspect of the leg. Above this point sensibility may be slightly disturbed, but is not lost, since the skin is supplied also by other nerves.

The Sciatic Nerve.—The sciatic nerve may be injured in a variety of ways. Though it lies behind the femur, it is very rarely injured in dislocations of

the hip, or in efforts at reduction. Stimson [1] was able to find but two recorded cases in which the muscles supplied by the sciatic nerve were more or less paralyzed in dislocations of the hip. It has been wounded, or divided a number of times in recent wars, by bullets. It may also be injured in fractures of the pelvis. I know of one case in which the sciatic nerve was divided in an operation for resection of a tuberculous hip-joint. If the nerve is injured the symptoms may be either complete or partial. It is to be borne in mind that the sciatic nerve consists of two parts, which remain separate and distinct as far upward as their origin from the plexus—namely, the external and the internal popliteal. In regard to gunshot wounds, the observations of Makins are interesting. He is quoted by Sherren [2] as follows:

> The most striking observation with regard to injuries of the great sciatic was the comparatively frequent escape of the popliteal element (internal popliteal) and the severe lesion of the peroneal. This was so pronounced as to amount to as high a proportion of peroneal symptoms as ninety per cent. Sherren adds that in a personal experience, which included sixteen cases of injury to the sciatic nerve, it was completely divided in only two. If the sciatic nerve is divided in the upper portion of the thigh some of the muscles on the posterior aspect of the thigh will be paralyzed. Usually, however, the paralysis is confined to the muscles below the knee, the rotators of the hip and the flexors of the leg escaping. All power of motion of the muscles of the leg and foot is lost and a peculiar gait is thus produced, the muscles of the hip being used to swing the leg forward as the patient walks. Sherren states [3] that "when divided at so high a point that the ham-string muscles are paralyzed, flexion of the leg on the thigh is still possible by means of the gracilis and that in old cases this muscle may greatly increase in size and furnish a fairly powerful flexor. Thus, in making the diagnosis of injury of the sciatic, it is desirable to test the activity of the individual muscles upon the posterior aspect of the thigh."

The sensory symptoms following division of the sciatic consist of a more or less complete loss or diminution of sensibility below the knee, involving largely the dorsum of the foot and ankle, and extending up upon the outer side of the leg nearly to the knee. The cutaneous distribution of the anterior tibial nerve is usually the chief seat of sensory disturbance.

The small sciatic nerve is quite rarely injured alone, but is often involved in injuries of the sacral plexus. Its division causes loss of sensibility over an area which includes the inner half of the buttock and extends downward in a somewhat narrow tongue nearly to the popliteal space.

The External Popliteal Nerve.—This nerve, on account of its superficial situation upon the outer aspect of the knee, is injured not infrequently as the result of wounds and contusions upon the outer aspect of the leg just below the knee, in fracture of the neck of the fibula, and occasionally, it is stated, as the result of muscular violence. As was mentioned in speaking of injuries

[1] L. A. Stimson, *loc. cit.*, p. 764. [2] Sherren, *loc. cit.*, p. 292. [3] *Ibid.*, p. 293.

of nerves in general, the nerve may be compressed by tight bandages, or by Clover's crutch or other apparatus used in the operation of perineal section. Sherren states [1] that "the nerve has been injured during tenotomy of the biceps tendon and during the correction of flexion deformity of the knee-joint, when the knee has been forcibly extended." Total division of the external popliteal nerve causes paralysis of the muscles of the front and outer side of the leg. The position of the foot is that of talipes equino-varus. The foot cannot be moved in dorsal flexion, nor pronated—i. e., everted, the unopposed action of the tendo Achillis causes strong plantar flexion of the foot, and, unless care be taken, contracture of the calf muscles will occur, with a permanent deformity. The muscles involved are the peronei, the extensors of the toes, and the tibialis anticus. In regard to the loss of cutaneous sensibility, Sherren states: [2]

Deep sensibility is unaffected, and the patient may be able to appreciate and to localize the slightest pressure causing deformation of the skin. Just before the nerve passes round the neck of the fibula it gives off a large lateral cutaneous branch; it is most often injured below this point. The loss of sensibility which results from this lesion is only absolute on the dorsum of the foot and lower third of the leg. The anterior boundary of the area insensitive to light touch is as well defined as after division of the whole nerve, but its posterior border and that on the outer margin of the foot merge gradually into parts of normal sensibility. Sensibility to prick is abolished over a triangular area on the dorsum of the foot, but is defective over an area almost as large as that anesthetic to cotton wool. After division of the nerve in this situation similar phenomena may be observed to those seen after division of the ulnar below its dorsal branch.

Division above the lateral cutaneous branch produces an area of loss of sensibility on the outer side of the leg and dorsum of the foot with well-defined boundaries, except at its external border in the lower third of the leg and outer surface of the foot, which territory it supplies in common with the external saphenous nerve. The boundaries of the loss of light touch and of prick are almost coterminous.

It is essential to remember the difference in the loss of sensibility that results from division above and below this branch. The small loss of sensibility that results from division in the latter situation is not sufficiently well recognized, and has lately led to the report of two cases of "immediate sensory recovery" after suture.

The Anterior Tibial Nerve.—The anterior tibial nerve, from its protected position in the upper part of the leg, is rarely injured in open wounds. It may, however, be pressed upon or torn in fractures of the tibia. Neuritis, etc., may follow. From its mere division no definite symptoms result.

The Obturator Nerve.—Partial lesions of the obturator nerve have been observed as the result of the pressure of the fetal head during prolonged labor or from the pressure of the blades of the forceps during instrumental delivery.

[1] Sherren, *loc. cit.*, p. 297. [2] *Ibid.*, p. 298.

It may also be compressed in thyroid dislocations of the hip. If the nerve is completely severed, there is paralysis of the adductor muscles of the thigh, with the exception, according to Sherren, of the flexor portion of the adductor magnus, which is supplied by the great sciatic. The sensory symptoms produced by irritation of this nerve occur as pain referred usually to the inner side of the knee, and, as elsewhere stated, often observed in hip-joint disease or other irritative conditions in the vicinity of the obturator foramen.

The External Cutaneous Nerve.—The external cutaneous nerve is occasionally injured by the pressure of a truss or from a violent muscular strain, and as a consequence a neuritis may develop in the distribution of the nerve attended by pain and changes in sensibility of the skin as well as paresthesiæ (Bernhardt's Disease).

The Posterior Tibial Nerve.—Isolated injury of the posterior tibial nerve is rare. When it is totally divided there will be loss of the power of plantar flexion of the foot and of flexion of the toes.

The Internal Popliteal Nerve.—Injury to the internal popliteal may occur as the result of severe injuries in the upper part of the popliteal space, and has occasionally been observed as the result of breaking up the ankylosis of a flexed knee (Sherren). The muscles paralyzed as the result of complete division of the internal popliteal are the muscles of the calf, the tibialis anticus, and the flexors of the toes. The foot assumes the position of talipes calcaneo-valgus. The loss of sensation, according to Sherren,[1] is as follows:

> There is no loss of deep sensibility after complete division of this nerve, but epicritic and protopathic sensibility are lost over the sole of the foot. This area has a well-defined inner border, but the outer border is ill defined owing to its overlap with the external saphenous. The dorsal surface of the outer four toes is insensitive to epicritic stimuli, but there is no loss of protopathic sensibility over their dorsal or plantar surfaces.

FRACTURES OF THE FEMUR

Fractures of the Shaft of the Femur

Under this head are included the fractures between the lesser trochanter above and the condyles below. The femur may be broken in any portion of the shaft, though fractures in the middle third are the most frequent, fractures of the upper third are next in frequency, and fractures of the lower third are least frequent of all. The bone may be broken at any period of life, though fractures are most common in men and during the age of greatest muscular activity—namely, between the twentieth and sixtieth years. They also occur with considerable frequency in children.

Fracture of the femur may take place from any of the forms of violence capable of breaking a bone, direct, indirect, or by muscular action, and all the

[1] Sherren, *loc. cit.*, p. 303.

varieties of fracture are here observed, though incomplete or green-stick fractures are very rare. Among adults, the line of fracture is commonly oblique. In children, transverse or toothed fractures of the shaft are not very rare. Multiple fractures are occasionally observed as the result of great degrees of violence, the femur being then usually broken into three large and separate fragments. There is a fracture of the upper third and a fracture of the lower portion of the middle third, or of the middle of the bone, below. Comminuted fractures are not infrequent and open fractures are not rare, either as the result of extreme degrees of violence, as in run-over accidents or the like, or from the subsequent penetration of the soft parts by the pointed end of the upper fragment which penetrates the muscles and may penetrate the skin, either as the result of the original violence, or from incautious handling of the fracture, or from muscular action.

Gunshot fractures of the femur are also frequent in time of war, those of the shaft being usually comminuted, with long lines of fracture running up and down the bone. Spiral fractures from twisting strains may also occur in the femur. In fractures by indirect violence, such as result from falls upon the feet or upon the knee, the middle portion of the shaft is frequently broken by an exaggeration of the normal curve of the bone. The line of the fracture is usually oblique, and may be very oblique, indeed, and runs from above and behind downward and forward. The lower end of the upper fragment is frequently pointed and sharp, and if the injury occurs when the knee is flexed, a continuance of the violence drives the pointed fragment downward and forward through the muscles, whence it may emerge through the skin. This latter accident constitutes one of the reasons why an originally simple fracture may be rendered compound by incautious handling. It may give considerable trouble in the reduction of the displacement, since the pointed lower fragment is caught in the muscles or in the skin, and may be very difficult to dislodge.

In fractures of the upper third, the line of fracture usually runs from above and behind downward and outward, or downward and outward and forward. Fractures of the upper third may also be combined with fractures of the base of the neck, a long, oblique line of fracture extending downward and inward from the base of the neck, so that a long, sharp, pointed fragment exists at the lower end of the upper fragment upon the inner side.

The displacements in fracture of the shaft of the femur are usually quite marked. In fractures of the middle third the lower fragment is, in most instances, drawn upward and backward, producing overriding, with an angular deformity, and often there is outward rotation of the lower portion of the limb. The overriding is also increased by the swelling of the thigh, which increases the diameter of the limb at the expense of its length. In fractures of the upper third, the upper fragment, being acted upon by the psoas iliacus and by the glutei, is flexed, abducted, and often rotated outward; the lower fragment, being acted upon by the adductors and flexors, is drawn upward and inward. In the treatment of fractures of the upper third this typical

displacement is very important to bear in mind, since it is by no means p
sible to bring the upper fragment down into apposition with the lower o

FIG. 195.—FRACTURE OF THE SHAFT OF THE FEMUR. Marked overriding. Internal aspect. (Anatomical Department of the Columbia University Medical College.)

FIG. 196.—FRACTURE OF THE SHAFT OF THE MUR. Union with overriding. Anterior of Fig. 195.

The lower one must therefore be *abducted* and placed upon a double incli
plane, or better upon a Hodgen's splint, in order to bring it into line w
the upper fragment.

The *signs and symptoms* of fracture of the shaft of the femur are, as a r
easy of recognition. The limb is powerless, and is often visibly shorte
Upon palpation, on account of the deep situation of the bone, surrounded a
is by thick muscles, it may be difficult, and often is impossible, to appreci
the relative position of the fragments. The sign of abnormal mobility

easily made out by placing the hand beneath the limb opposite the supposed point of fracture and gently lifting it, when the abnormal point of motion is usually at once apparent. At the same time the sensation of crepitus is often heard and felt. The loss of continuity may also be established by gently lifting the leg, when the mobility and angular deformity are readily apparent. Rotary movements of the leg will also serve to establish the presence of fracture by noting that the trochanter does not follow the movement of the lower fragment. All the other signs of fracture are present—localized pain and tenderness and ecchymosis. Here, as in other fractures, it is unwise to seek too strenuously for the sign of crepitation, lest a greater injury be done to the soft parts of the limb.

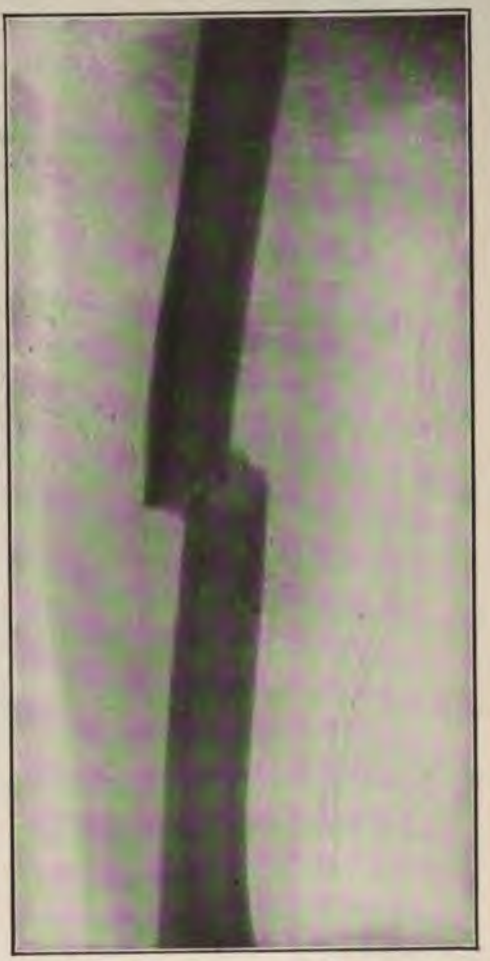

FIG. 197.—FRACTURE OF THE SHAFT OF THE FEMUR. Slight lateral displacement. (New York Hospital collection.)

In compound fractures of the femur, such as occur from great degrees of violence, the laceration of the soft parts is of variable extent. It rarely happens that the femoral artery or vein is injured, since they are not in sufficiently close apposition to the bone to be wounded, except at the lower end.

The examination of a fracture of the femur should be conducted with great care and gentleness. It is customary and wise to postpone the thorough examination until such time as an anesthetic can be given and the limb placed in a permanent dressing of one or other character, according to the indications. The most positive and important sign in fracture of the femur is the shortening, due in part to overriding and in part to the angular displacement. This is determined in the same manner as when examining for fracture of the neck of the femur, or in hip-joint disease, elsewhere described in this book, in Vol. I and in Vol. III. The position of the patient and the care with which the measurements are taken are highly important. As has been elsewhere stated, the examination should be made upon a flat, hard surface, preferably a table, a hard, smooth bed, or upon the floor. The entire body should be straight, the

limbs in the same relative position in respect to the pelvis, and the pelvis itself not tilted. The precautions used in making the measurements have been elsewhere described. The degree of shortening found varies greatly in different cases, and may be anywhere from a fraction of an inch to several inches. In transverse fractures such as occur among children, if the bony fragments are interlocked, or not separated laterally, there may be little or no shortening, but only angular deformity. If, however, the lateral displacement is sufficient to separate the broken ends, there will be angular deformity, with overriding. Although by no means necessary for a diagnosis, the X-rays are exceedingly

FIG. 198.—FRACTURE OF THE SHAFT OF THE FEMUR; UNION WITH ANGULAR DEFORMITY. (Collection of Dr. C. L. Gibson.)

valuable in cases of fracture of the shaft of the femur for the purpose of determining whether the fragments are held in proper position by the apparatus applied, and this will often furnish the surgeon with very important hints as to treatment. It is to be borne in mind that there is nothing absolutely regular about the direction of angular displacement in fractures of the femur. The

displacement will depend to a very great extent upon the direction of the line of fracture.

In fractures of the lower third the chances of the injury becoming compounded by the projection of the lower end of the upper fragment through the skin are greater than elsewhere. Fractures in this region, also, are more apt to be complicated by injury of the artery or vein, and it is well in every instance to test the pulsation of the dorsalis pedis. In the very rare cases of incomplete fracture, whether in children or in adults, the signs of overriding will be absent, though angular deformity is usually present, or may be made to appear upon manipulation. In cases of doubt the X-rays are the most certain means of diagnosis.

FIG. 199.—FRACTURE OF THE SHAFT OF THE FEMUR IN A CHILD; UNION WITH SLIGHT OVERRIDING. Note the periosteal bridges. (Author's collection.)

The *treatment* of fracture of the shaft of the femur is important, but I do not feel that it requires attention in a work on diagnosis.

The *prognosis* of fracture of the shaft of the femur is in general favorable although it must always be regarded as a serious injury, and if compounded or associated with extensive laceration of the soft parts, or of the blood-vessels, it may be very serious, or even fatal. It is usually impossible to promise a patient with fracture of the shaft of the femur that union will take place without shortening. Such may be the case, but no plan has as yet been devised by surgeons which will render such a result a certainty. A shortening which may amount to from half to one inch is not infrequently observed, and does not, as a rule, interfere with the function of the limb.

INTERCONDYLOID FRACTURES OF THE FEMUR

The intercondyloid fractures of the femur occur from falls upon the lower end of the bone, as the result of which it is supposed that a fracture of the

lower portion of the shaft takes place, and that by a continuance of the violence the shaft splits the lower end of the femur in two, so that usually a Y- or T-shaped fracture is produced, though the main fracture of the shaft may be more or less transverse. The separation of the condyles is vertical and occurs through the intercondyloid notch. There is usually complete separation of the condyles, and they may be forced upward on either side of the wedge-shaped lower end of the upper fragment. Usually the condyles, together with the leg, are displaced backward. The lower end of the upper fragment frequently enters the knee-joint, and the condyles may even be displaced so far upward that its sharp point projects through the skin. The recognition of the fracture is usually easy. The deformity is, as a rule, quite marked, and the lower end of the upper fragment can frequently be felt projecting under the skin, or even caught therein. The condyles can be grasped and moved independently of one another upon the lower end of the shaft. The leg follows the condyles.

FIG. 200.—OBLIQUE FRACTURE OF THE LOWER PART OF THE SHAFT OF THE FEMUR; UNION WITH SLIGHT DISPLACEMENT. (Author's collection.)

In a case upon which I operated two years ago, the patient, a man aged thirty years, had been at work at the top of a rather high ladder when the support gave way and he fell to the ground striking upon his flexed left knee. He was unable to use the limb, and was brought to the hospital by the ambulance. The knee was flexed and greatly swollen and the leg with the condyles was displaced backward. The lower end of the upper fragment could be felt caught in the skin upon the anterior aspect of the limb. The knee was greatly swollen, and measurement with a pair of calipers showed that the transverse distance across the condyles was greater upon the injured side. Efforts at reduction under anesthesia failed, so that I made a cut upon the front of the limb and found a long sharply pointed lower fragment which lay between and rather widely separated the condyles, projecting into the knee-joint. A loose fragment of the posterior part of the shaft about two inches long and half an inch wide was removed. The pointed end of the lower fragment was sawn squarely across about two inches above its lower extremity, the condyles were drilled and

sutured together with catgut and brought into contact with the squared end of the shaft. The limb was put up in a fixed dressing, the knee slightly flexed, and primary union was obtained. At present, two years after the operation, there is an inch and a half of measured shortening and flexion at the knee-joint is possible to an angle of about 40°. The patient, however, complains of some pain when using the limb continuously, and has not returned to his work, nor to any particular occupation, being influenced by the fact, perhaps, that a suit for damages is pending.

Separation of the Epiphysis

Separation of the lower epiphysis of the femur is a relatively frequent injury as compared with similar accidents in other parts of the body. The injury occurs up to the twentieth year of life, and is usually caused by great degrees of violence, such as falls from a height, or, in a peculiarly large number of cases, as noted by Stimson, and in one case of my own upon which I operated in the New York Hospital, the fractures occur as the result of getting the limb caught between the spokes of a moving wheel. A few cases have also been reported as the result of violence to the legs of the infant during the delivery of breech presentations. Stimson states that the form of violence usually acts by hyperextending or abducting the knee, the epiphysis being thus torn away from the diaphysis.

The fracture occurs through the epiphyseal cartilage at the lower end of the shaft, and usually the periosteum of the shaft is rather extensively torn, remaining attached below to the epiphysis. The condyles are, as a rule, displaced forward or forward and to one or the other side. The displacement may be only partial or, on the other hand, the condyles may ride upon the anterior surface of the lower end of the shaft, as in one case reported by Charles McBurney (*Annals of Surgery*, March, 1896). In this case reduction was only accomplished after incision, a periosteal elevator being used to pry the condyles free from the shaft. In my own case the patient was a little boy, aged nine years. The injury had been caused by the child slipping while getting out of a wagon, so that his leg passed between two of the spokes of the wheel, which, continuing to revolve, produced the injury. Efforts to reduce the anterior displacement under ether failed, and I reduced it by an open operation, when by traction with a bone hook and direct pressure the fragment was replaced, and so long as the knee was kept slightly flexed, the displacement did not tend to recur.

The displacement may in some cases be quite complicated, so that the condyles are rotated upon a vertical axis, and one of them may point forward while the other occupies the popliteal space. In other cases the fractured surface may be directed backward. The injury is a serious one from many points of view. Compression or laceration of the popliteal vessels is not very rare, and interference with the subsequent growth of the bone is common. The

recognition of the nature of the injury is usually simple, unless sufficient
has elapsed for the production of great swelling. In the ordinary for
displacement the upper border of the condyles forms a projecting ridge in f
while the contour of the lower end of the shaft may be felt and identifie
the popliteal space or to the outer or inner side. If the fractured surface

FIG. 201.—SUPRACONDYLOID FRACTURE OF THE FEMUR. Formation of abundant osteophytes. Anterior view. (Anatomical Department of Columbia University Medical College.)

FIG. 202.—EXTERNAL ASPECT OF THE
SHOWN IN FIG. 201. (Anatomical
ment of the Columbia University Medic
lege.)

be brought into contact and moved one upon the other, the character of the
itus is sufficient to indicate the nature of the injury, since it is soft and not
unless the separation is complicated by a line of fracture through the lowe
of the shaft, such that a bony fragment remains attached to the epip
In a good many instances the injury is compound, when its nature w

readily recognized during the operative measures necessary for treatment. The upper fragment usually penetrates the skin in the popliteal space.

Fracture of a Single Condyle

Fracture of a single condyle of the femur is a rare injury. It may be produced either by direct violence, as from a fall upon the knee, or by traction, as when the knee being bent to one side the lateral ligament tears away one or other condyle, or it may be caused by the direct pressure of the tibia against the condyle on the side toward which the leg is bent (Stimson). The injury is attended by the ordinary signs of fracture, pain, tenderness, loss of function, mobility, deformity, and crepitation, and in the cases in which much displacement exists the diagnosis is very simple. In some cases, however, there is little or no displacement since the condyle remains attached to the tibia, and its attachments to the femur may be only very slightly torn. In these cases as in all apparently serious injuries in the vicinity of the knee-joint, the X-rays will clear up the diagnosis. In the cases with displacement, the condyle may be displaced forward or backward, or directly to one side. In the first two groups the deformity at the knee-joint and the position of the leg will at once indicate a serious injury, and palpation will readily make out the presence of a displaced mass of bone attached to the tibia, the fractured condyle. Stimson states[1] that in the reported cases the results have varied greatly. In some the fracture has united without more trouble than after an ordinary fracture not involving a joint; in others suppuration has occurred and terminated fatally. The treatment of the condition is the reduction of the displacement by manipulation of the leg and of the fragment, and putting it up in a fixed dressing in such a position that the displacement does not tend to recur. Stimson prefers the position of extension of the knee.

GUNSHOT WOUNDS OF THE THIGH

For the general characters of gunshot wounds the reader is referred to Vol. I. As was there pointed out, great differences exist in the gravity of gunshot wounds, not only according to the character of the weapon, and of the bullet, and of the range at which it is fired, but also when the missile strikes a bone, according to the portion of the bone struck, whether the spongy extremities or the hard shafts of long bones.

Modern military rifle bullets, so long as they do not stroke the femur or wound important vessels or nerves, and the wounds remain uninfected, produce injuries of very slight gravity, which tend to heal by first intention. Soft-nosed bullets and large soft-lead bullets, fragments of shell, or bullets already deformed by ricochet, produce injuries of the soft parts, attended by a greater or less laceration of tissue, by much larger wounds of entrance and exit, and by a

[1] L. A. Stimson, *loc. cit.*, p. 331, 1907.

far greater likelihood of infection with its subsequent dangers. Small-calibered rifle bullets which penetrate the femoral artery may be followed by immediate death from hemorrhage, or by a traumatic aneurism with the results which have elsewhere been described. Arteriovenous aneurism is also possible, as recorded in several cases. They will produce the ordinary symptoms. (See Aneurism.) In recent wars wounds of nerve trunks have been observed, as elsewhere stated, and the most frequent nerve injured is the great sciatic. Usually but a portion of the nerve is cut, or the bullet passes through the middle of the nerve trunk, causing a small perforation. The immediate symptoms are pain and partial disturbances of motion, and sensation in the area supplied by the nerve. There is a tendency in some of the cases to the production of a neuritis. As already mentioned under Gunshot Wounds of the Pelvis, in modern warfare gunshot wounds of the thigh may occur, which enter the outside of the thigh near the knee and pass upward, emerging through the buttock, having passed through the pelvis. The gravity of these injuries will, of course, depend upon whether they strike bones or other important structures. The mere passage of the bullet through a long track in the soft parts does not apparently add to the gravity of the injury.

Gunshot Wounds of the Femur

Gunshot wounds of the femur have been frequent in all recent wars, and on account of their severity, and the large mortality following these injuries and the difficulty of treating them properly upon the field of battle, or in field hospitals, they have always been extremely interesting to surgeons. The following statistics in regard to gunshot fractures of the femur are quoted from Scudder: [1]

The operative mortality following compound or open fractures of the femur during the Crimean War was about 73 per cent. During the American War it was about 53 per cent. During the Franco-German War it was 65 per cent among the Germans and 90 per cent among the French. The conservative mortality—i. e., in the unoperated cases—was under these same conditions: Crimean War, 72 per cent; American War, 49 per cent; Franco-German War: German, 28 per cent; French, 9 per cent.

In the war with Spain in Cuba the general mortality of operated and non-operated cases was only about ten per cent, and in the war between the Russians and the Japanese it was even less than that. Makins's "Surgical Experiences in South Africa," in a comment upon the results of gunshot fractures of the femur, says:

As regards mortality, fractures in the upper third of the bone proved one of the most formidable injuries which came under treatment. Suppuration was common, at least sixty per cent of the wounds becoming infected. This depended on

[1] "The Treatment of Fractures," by Charles L. Scudder, sixth edition, p. 520.

several reasons, often inseparable from the injuries or from their treatment in field hospitals, such as (1) the exit wound being situated in the dangerous region of the thigh; (2) ineffective dressing and fixation; (3) the impossibility of insuring primary cleansing and removal of detached fragments of bone; (4) the necessity of the early transport of patients to the stationary or base hospitals, often for great distances; (5) the comparatively long period that often had to elapse before the opportunity of doing the first efficient dressing arrived. Fractures in the middle and lower thirds of the bone were more easy to treat successfully, but these also added to the list both of amputation and fatalities. Punctured fractures of the lower articular extremity were usually of little importance, as they progressed without exception, as far as my experience went, favorably.

These results are in accord with the general experience of the effects of small caliber high-powered bullets upon the long bones. Upon the spongy extremities of such bones the bullet, as a rule, makes either a clean perforation or but little comminution, and if the wound is at once protected by an occlusive dressing, and the patient is not moved about until the limb is properly immobilized, the injuries heal with extraordinarily little reaction, even when they pass through the knee-joint, as has been observed in a number of cases during recent wars. If, on the other hand, the bullet, while moving at high velocity, strikes the hard shaft of the bone, it will pulverize the portion of the shaft struck and will cause fissures running up and down for considerable distances. As was pointed out when speaking of gunshot wounds of the humerus, if the bullet is moving at a slightly diminished velocity the fissures will usually be more extensive, and pass for greater distances up and down the shaft and the separated fragments at the point of impact will be larger. In both these groups the degree of laceration and destruction of the soft parts is often extreme, blood-vessels, nerves, and muscles being extensively torn by the small bone fragments or sometimes by the bullet itself. In the diagnosis of these fractures, it is to be borne in mind that the injury to the soft parts is often more important than the injury to the bone, and that such injuries may be very extensive of the deeper structures, though the wounds of entrance and even of exit may be quite small. The situation of the bullet if lodged, the direction and extent of the lines of fracture, and the degree of comminution can be best appreciated by means of an X-ray examination, if such be practicable. Lodgment of the projectile, or of a portion of it, is more apt to occur from wounds made by grape-shot, by fragments of shell, or by bullets which have lost a portion of their velocity by ricochet.

The prognosis is, to an enormous extent, dependent upon whether or not the wound remains aseptic. In a large proportion of cases the amount of shock following gunshot fractures of the femur is very marked, and where extensive comminution exists the mobility is great; the limb upon palpation may seem to consist of a mere bag of bones. It was noticed by Makins that immediately following the injury all the muscles of the limb were paralyzed, so that there was little or no tendency to the production of shortening, though much com-

minution had occurred. After a few days, when the muscles recovered their tone, the shortening in some cases became very marked indeed. In the treatment of these fractures the most important element is the avoidance of infection, best accomplished, under the difficult conditions of the battlefield, by an occlusive dressing. The longer the transport of the patient can be delayed, and the less the wounded limb is moved about, the better. The ideal treatment, as suggested by Sir William MacCormac, of such cases would be to erect a tent over the wounded man and not transport him at all. If transportation is necessary, both thighs should be immobilized by long side splints extending from the axilla to below the feet, and additional fixation may be secured by other splints laterally and posteriorly, or by plaster of Paris, if such is at hand. (See also, appendix.)

CHAPTER XX

DISEASES OF THE THIGH

ANEURISMS OF THE THIGH

In a former chapter we have described the aneurisms of the groin, and shall here speak of aneurisms of the superficial femoral—femoral aneurism. A large proportion of the aneurisms of the femoral are of traumatic origin, though the ordinary causes of aneurism, syphilis, alcoholism, arteriosclerosis from any cause, are responsible for a certain proportion of the cases. While the aneurism is usually solitary, several aneurisms have been observed in the course of the artery in the same case. The aneurism may develop on the main trunk or occasionally upon the profunda. The relative frequency of femoral aneurism as compared with popliteal aneurism is about 1 to 4, popliteal aneurism being thus much more frequent. In Crisp's statistics there were 66 cases of femoral aneurism, and of these 21 were classed as femoral or femoro-popliteal; 22 were said to have been in the groin, 4 near the groin, and 19 in the upper third. It will thus be seen that the upper portion of the vessel is more frequently affected than the lower part, probably on account of its more superficial position being thus more exposed to injury and over this area also to stretching. Aneurisms developing in the superficial femoral at or near the apex of Scarpa's triangle are ordinarily globular in shape. Those which are farther down cannot so readily expand, and are flattened to a greater or less extent.

Symptoms.—The symptoms during the early stages of femoral aneurism are slight. Usually the patient's attention is attracted to the tumor in the course of the artery by pain or by paresthesiæ along the inner side of the thigh and leg. Edema of the extremity may develop, though it is far less common than is the case with popliteal aneurism. The tumor itself gives the ordinary signs of aneurism, elsewhere described, and the posterior tibial pulse felt behind the inner malleolus is felt weakened or delayed upon the affected side. The sphygmographic tracing is usually characteristic. It is at times difficult to distinguish between an aneurism of the femoral and one of its profunda branch. If the aneurism is situated upon the main arterial trunk, changes in the pulse should be observed in the vessels below, and such would probably suffice for a diagnosis, although in the reported cases the mistake has nearly always been made of supposing that the aneurism of the profunda was on the main vessel. Cold abscesses or other cystic masses overlying the femoral artery receive a

transmitted pulsation, so that in some instances an aneurism has been mistaken for an abscess or *vice versa*. The course of the disease is toward final rupture and death.

Arteriovenous Aneurism.—Arteriovenous aneurism is occasionally observed as the result of injury in the thigh. There will be the history of a stab or punctured wound, or other characteristic accident, and the development of the signs of arteriovenous aneurism. (See Vol. I.)

VARICOSE VEINS OF THE THIGH

Although more common in the veins of the leg, a varicose condition of the veins of the thigh, notably of the internal saphenous vein, is sufficiently common. The greatest dilatation in the vein is usually just as it enters the cribriform fascia to join the femoral vein, though the vein may be dilated throughout its length. The signs of varicose veins of the thigh are perfectly characteristic. The enlarged and dilated vein can be seen and felt beneath the skin. Opposite the saphenous opening a very considerable swelling may be formed which may give an impulse on coughing, and which may be mistaken for a femoral hernia. For the differential diagnosis between these conditions see Hernia, Vol. II. A wound or rupture of a varicose saphenous vein may, in the absence of proper treatment, be a very serious accident indeed. Dangerous and even fatal bleeding has occurred under such circumstances. The recognition of the condition is, of course, entirely simple upon inspection.

LYMPHANGIECTASIS, LYMPHADENOCELE OF THE GROIN, ELEPHANTIASIS

We have elsewhere spoken of the effects of lymphatic obstruction in the groin, the result of removal of the lymph nodes of this region, and of those cases due to obstruction of the lymph vessels in cases of filariasis. By the terms lymphangioma and lymphangiectasis we ordinarily understand a dilatation of the lymphatic vessels held within a connective-tissue framework, and by the name lymphadenocele we designate a similar affection of the lymph nodes. Such conditions are observed in the thigh with moderate frequency. For their pathology the reader is referred to Vol I, under Tumors. The nonparasitic cases of lymphangioma produce in the lower extremity extraordinary deformities. (See Fig. 203.) In the majority of instances we are not able to determine the cause in the individual case, when obstruction, due to filariasis, the pressure of tumors, and the removal of the lymph nodes can be excluded. The diagnosis of the presence of the condition is readily made upon inspection. The only cases of this general description in which any difficulty of diagnosis is likely to exist are the lymphadenoceles. The true nature of the mass is often missed until it is operated upon. It presents as a more or less circumscribed or diffuse, harder or softer mass in the groin. Dilated lymph vessels leading to the tumor

are sometimes observed, and the condition may be bilateral. According to Dowd ("American Practice of Surgery," Vol. II, page 577), lymphadenocele of the groin has been mistaken for a venereal bubo, an omental hernia, a cold abscess, a lipoma, a venous erectile tumor, or a deep-seated lymphangioma. Dowd states that Ashford found that in many of the cases which he saw among soldiers the condition was believed to be a venereal bubo. A careful study of the case, its extremely chronic character, and its merely superficial resemblance to the conditions above noted should enable the surgeon to make a probable diagnosis. Incision and extirpation of the mass, together with pathological study of the removed tissues, would make the diagnosis quite clear.

FIG. 203.—ELEPHANTIASIS OF BOTH LEGS. No known cause. (Kindness of Dr. F. G. Beck, New Haven, Conn.)

MYOSITIS OSSIFICANS OF THE MUSCLES OF THE THIGH

The muscles of the thigh are a favorite localization for the formation of bony or calcareous nodules and plates resulting, as a rule, from oft-repeated traumatism. While the adductors are most often the seat of these bony growths, other muscles of the thigh—the extensors, and sometimes the flexors—may be involved. (See Fig. 194.) The affection is most often observed among cavalrymen, who are obliged to ride much, and who hold the thigh firmly against the saddle. As the result of the repeated mechanical insults, there may develop more or less massive nodules or plaques in the muscles or in their tendons.

The recognition of the condition is simple. Upon palpation the hard mass is readily felt and may be demonstrated easily by an X-ray picture. If the bony nodules are situated in the muscular belly they will be movable, if in

the tendons close to the bone they will be less so, or if, as in the case shown in Fig. 194, they are attached to the femur, they will be immovable. If in such a case as is figured in the text a fracture of this bony growth took place, it would surely puzzle the examiner until an X-ray picture had demonstrated the condition.

SCIATICA

Sciatica, or neuralgia of the great sciatic nerve, while not distinctly a surgical condition, is sometimes treated and cured by surgical means, and, moreover, sciatic neuralgia occurs as a symptom in several conditions which are distinctly of a surgical character. The disease is a very common one. It affects males more often than females, and as a pure neuralgia is most frequent in men, and during middle age. The disease may be due to a great variety of causes, among which may be mentioned injuries of the trunk of the nerve, as contusions, more rarely open wounds, whether stab or gunshot. It may also occur as the result of violent muscular strains which stretch the nerve unduly. It is occasionally seen as an occupation affection among those whose work requires that they should remain for a long time in a squatting attitude. Sciatica may, as the result of pressure, complicate many intrapelvic conditions. Tumors, inflammatory exudates, either connected with the pelvic organs of the female or due to disease of the pelvic bones, may all be accompanied by pain in the course of the sciatic nerve. It is often observed as a symptom in conditions of congestion of the portal system, whether due to cirrhosis of the liver or to malignant disease within the abdominal cavity, etc. Pain in the course of the nerve is also present in some cases of extensive varicose veins of the lower extremity.

As *a pure neuralgia,* sciatica may be caused by various toxemias, among which may be mentioned alcoholism, and it is believed also gout and rheumatism. In the multiple neuritis due to chronic alcoholism the sciatic nerve is often the seat of pain. It is not always possible to distinguish between those cases which are pure neuralgias and those which are the result of an acutal inflammation of the nerve. The longer the disease remains, in spite of treatment, the more likely is it due to an organic cause. Starr states [1] that, "in all the cases in which the autopsy has been obtained, an interstitial neuritis with congestion of the vessels, hemorrhages into the sheath, secondary degeneration of the nerve fibers have been found." In a large proportion of cases, however, the duration of the disease is so short and is characterized by such sudden intermissions that the presence of organic changes in the nerve is improbable.

Symptoms.—The symptoms of sciatica are pain in the course of the sciatic nerve, and in some cases in its cutaneous distribution. In most instances the pain is a deep-seated one, *not referred to the skin,* and is most intense along the back of the thigh and at the point of emergence of the main trunk from

[1] Starr, "Organic Nervous Diseases," first edition, p. 93.

the pelvis. The pain may be limited to the course of the nerve as far down as the knee, or, in other cases, it will be referred to the sciatic distribution in the leg and foot. In addition to the pain, the nerve is tender on pressure, especially at those points where it may be compressed against firm underlying structures, as at the sciatic notch opposite the gluteal furrow, between the trochanter and the tuberosity of the ischium. If the entire distribution of the nerve is involved, there may be tenderness on pressure also over the neck of the fibula and behind the inner malleolus. There is usually tenderness throughout the course of the nerve upon deep pressure along the back of the thigh. The pain is rendered much worse by flexion of the thigh on the pelvis, the knee being extended. The pain is sometimes constant, sometimes remittent, but there are in most instances acute attacks of sudden severe pain in addition. In some cases the pain comes on slowly and gradually, and becomes worse and worse for a number of days. In others the acute, sudden attacks of pain are more marked, the patient being fairly comfortable in the intervals. In severe cases the patient may be quite incapacitated for work, or may be confined to the house or even to his bed. If the pain is severe, the patient will limp while walking and will hold the thigh quite stiffly. The body is bent toward the sound side instinctively in order that the weight of the trunk may not fall upon the affected limb. In chronic cases there may be quite a marked habitual deformity. The position is thus described by Starr:[1]

> In sciatica the thigh is somewhat adducted, the fold of the buttock is depressed, and the knee is slightly flexed, even when standing in an upright position. The entire spine is somewhat deflected with the convexity toward the affected side. This is due to an instinctive effort to support the weight on the well limb. There is sometimes a slight wasting of muscles in the limb.

Differential Diagnosis.—The differential diagnosis of sciatica is rather important for the surgeon, since a number of conditions of a more serious character may be accompanied by pain in the course of this nerve. It may be distinguished from sacro-iliac disease by the fact that in sciatica crowding of the pelvic bones together does not increase the pain. The pain of hip-joint disease is usually referred to the inner aspect of the thigh and knee-joint in the distribution of the obturator nerve; not in the course of the sciatic, nor is the sciatic nerve necessarily tender in inflammations of the hip-joint. The affections of the cord and of the cauda equina, whether inflammatory or due to the pressure of tumors, are, as a rule, bilateral. Sciatica may be so, but this is exceptional. I have seen one such case, which I cured by stretching both sciatic nerves through incisions.

The serious affections of the cord and cauda are attended by disturbances of sensation in the distribution of the nerve, anesthesia, etc., and in many cases also there will be paralyses of muscles, or of groups of muscles, sometimes dis-

[1] Starr, *loc. cit.*, p. 95.

turbances of the functions of the bladder and rectum. It is always important to eliminate locomotor ataxia when a patient comes complaining of pain in the course of the sciatic nerve, since, although the pains of locomotor ataxia are more commonly felt in the distribution of the nerves upon the front of the thigh, sciatica is sometimes an early and severe symptom. The loss of knee-jerks, the pupillary changes, and the areas of anesthesia, or blunting of sensibility regularly observed in locomotor ataxia, are absent in sciatica. As stated, the more persistent the condition, the more likely is it due to an organic cause. A great many methods of treatment have been tried in sciatica. In my own experience, baking of the limb, application of the actual cautery along the course of the nerve, and, in the most obstinate cases, exposing the nerve in an incision, stretching and liberating the adhesions which are often found at the point where the nerve emerges from the sciatic notch, have been most successful. Stretching, however, failed entirely in one case.

BLASTOMYCOSIS

A description of this condition was inadvertently omitted from Vol. I of this work, and since in the case figured in the text, through the kindness of Dr. George Woolsey, the lesions were situated upon the skin of the thighs and buttocks, it may well be briefly described in this place. Blastomycosis, sometimes spoken of as blastomycetic dermatitis, psorospermiasis, and saccharomycosis, is a comparatively rare disease, caused by the growth in the tissues of a yeast fungus. Probably several varieties of these fungi are capable of producing similar lesions. In man, the disease may infect the integument as a chronic inflammatory process, or in a few cases it has given rise to tumors in the internal organs, and in one case, reported by G. Brewer, tumors resembling somewhat sarcomata, situated in the spine. The lesion produced upon the skin is a chronic inflammation, accompanied by the formation of granulation tissue, and attended by superficial suppuration. It is quite important to recognize the condition in order that it may be differentiated from tuberculosis of the skin (Tuberculosis Verrucosa Cutis, see Vol. I), from some of the forms of epithelioma, and from the later lesions of syphilis. This differentiation can be made by the recognition under the microscope of the characteristic fungi. The lesions upon the skin are in the nature of a papillary dermatitis with the formation of minute abscesses, which, beginning as a small papule, soon takes on a pustular character and tends to spread continuously over the surface, and to produce by inoculation other similar foci in the vicinity or on distant parts of the body. The lesion is slightly elevated, soon becomes covered with a crust, and progresses slowly until a large area or areas of skin may be involved. When the scab is removed the surface of the lesion has a warty appearance, is soft, somewhat elevated, and shows scattered minute abscesses. The border of the lesion exhibits the characters of a chronic inflammation, the skin is dark red, and the redness and infiltration end abruptly in the healthy surrounding in-

tegument. Upon squeezing the infiltrated parts, little drops of muco-pus may be made to exude from the abscesses.

The *diagnosis* must be made microscopically, either by finding the fungi in the pus, or after excision of the lesion, in the tissues. When the pus is examined under the microscope the fungi are found free; when sections of tissue are used

Fig. 204.—Blastomycosis of the Thigh and Buttocks. Duration of the disease eight years. Recurred three months after operative removal. In addition to the active lesions, the scars of former operations may be seen. The case improved under the use of iodid of potassium internally. (Kindness of Dr. George Woolsey.)

for diagnosis the fungi will be found chiefly in the giant cells, which are abundant, and occur in this as in other proliferating skin lesions. In examining the pus a drop of it is placed upon a microscope slide and to it is added a thirty-per-cent solution of sodium hydrate. Upon this is placed a cover glass, and the specimen is examined without staining. The fungi appear as rounded, double contoured, highly refractive bodies, which measure from 7 to 20 μ. They may be seen in groups, or in pairs, or singly in the microscopic field. So long as the disease is confined to the integument, the general health does not appear to suffer materially, but if the organism invades the lungs or other internal organs the condition is serious and often fatal. The disease shows a peculiar tendency to recur after operative removal. In the case shown in Fig. 204 the scars of former operations are readily seen. The patient was a negro man who had suffered from the disease for a number of years.

The *treatment* of blastomycosis is partly operative and partly medical. Large doses of iodid of potassium up to 500 grains a day have been successful. Bevan recommended, and used with good results, sulphate of copper both ex-

ternally as a wash in a one-per-cent solution, and internally in doses from one quarter to one half a grain three times a day. The condition belongs more properly to diseases of the skin, and yet it will occasionally come under the observation of the general surgeon and he should be able to recognize it. When the fungus develops in the deeper structures it may give rise to subcutaneous nodules, or deeper placed tumors having the gross appearances of a myxosarcoma.

ACUTE OSTEOMYELITIS OF THE FEMUR

Acute osteomyelitis of the femur occurs in about forty per cent of the cases of acute osteomyelitis of the long bones. In other words, the femur is a frequent localization for this disease. The part most often affected primarily is the lower portion of the shaft, whence the infection spreads upward and downward. For the pathology and course of the disease in general the reader is referred to acute osteomyelitis, Vol. I. When the disease is localized in the femur, the general septic symptoms are apt to be severe. The disease begins here, as elsewhere, with the sudden onset of fever, also with chills, and is characterized by the presence of acute and agonizing pain referred to the affected thigh. In the cases which survive the general septic process, the whole limb rapidly swells, the subcutaneous veins are dilated, and here, as elsewhere, redness of the skin is usually absent. Swelling may, however, be delayed, and hence arise errors in diagnosis. The limb is powerless; the slightest movement causes a marked increase of pain unless the mental condition of the patient be so dulled that he does not react to ordinary stimuli. In former days the condition was frequently confounded with typhoid fever. At present the leucocyte count affords valuable aid in diagnosis. Perforation of the periosteum occurs after a variable period, depending upon the intensity of the infection. In the most acute cases a diffuse suppurative process of the soft parts of the thigh may be present in from ten days to two weeks after the onset of the disease. In other cases such perforation, if the disease is subacute, may be long delayed. (See case described of subacute osteomyelitis of the femur, Vol. I, page 183.) Here, as in other bones, the mistake is sometimes made of supposing that the suppurative inflammation of the soft parts is the primary condition. In every case of doubt it is the duty of the surgeon to inspect the femur over a considerable area and to make a small opening with a trephine, gouge, or other suitable instrument through the cortical layer of the bone, when, should osteomyelitis be present, pus, usually under tension, will pour forth. If a single opening is not sufficient to discover the presence of infection of the medulla, several minute openings may be made at different points. As was pointed out in Vol. I, a very valuable guide as to the center of the process—that is to say, the primary point of infection—is the discovery of the *area of greatest tenderness upon palpation along the shaft of the bone.* This will not be quite so easy in the case of the femur as in the case of more superficially placed bones, but I have always found it a useful guide in determining the site of incision. In a good many cases after

incising the soft parts, it will be found that the periosteum is thickened, congested, and loosened from the surface of the bone. In other cases incision of the periosteum will permit at once the escape of pus, and, in still others, the periosteum will be found loosened and the underlying bone not of its normal pinkish white, but of a dead white or slightly greenish-yellow color. As was stated in Vol. I and Vol. III, involvement of the knee-joint, or of the hip-joint, either as an acute serous synovitis, or, later, as a purulent arthritis, may take place in the course of the disease. The local signs and symptoms of these conditions have been elsewhere described.

The *treatment* of the acute cases is early incision and the construction of a canal in the long axis of the bone, which will give entirely free exit to the pus, followed by cleaning out of the infected medulla and disinfection with hydrogen peroxid. The wound should be left largely open. In neglected cases, if the patient survive, the soft parts of the limb will finally be perforated with the escape of abundant pus. In these the entire shaft of the bone may undergo a subsequent necrosis and become covered by an involucrum of new bone, through which cloacal openings leading to sinuses are formed. If operated upon early, the subsequent history of the cases which survive is usually not unfavorable. The amount of necrosis will vary, of course, in different cases, but usually it will be confined to the formation of one or more superficial sequestra. These take the form of thin, long scales of bone, more or less worm-eaten at their borders. In other cases the sequestra will be more massive, and will involve a considerable portion of the thickness of the shaft. The size of the sequestrum may often be inferred from the distribution of the sinuses upon the surface of the limb. The farther apart such sinuses are, and the greater their number, the more the likelihood that the sequestrum is of considerable size. Occasionally, in neglected cases, several large or smaller sequestra will be formed along the shaft. A good X-ray picture of the bone will often aid the surgeon greatly in planning his incisions for the removal of the dead bone. The separation of the sequestrum in osteomyelitis of the femur takes place in from two and a half to six months, depending upon the local conditions in the individual case. Examination with a probe previous to operation is to be avoided as far as possible. It is desirable to remove the sequestra at a time when they have separated from the surrounding new bone, for two reasons: If the operation be done at too early a period it may happen that more than the necessary amount of bone will be removed, with a possible resulting spontaneous fracture. If, on the other hand, the operation be too long delayed the patient suffers from the depressing effects of chronic sepsis, and may develop amyloid degeneration of the kidneys, liver, and spleen.

As the result of osteomyelitis of the femur, deformities of the bone may result, in the nature of curvatures, depending for their situation and direction upon the anatomical site of the lesion. Thus, coxa vara, anterior or lateral curvature of the upper portion of the shaft, may result, or, in the lower end of the bone, a sharp curvature just above the condyles with its convexity forward or

forward and outward. In addition to deformities of this character, the involucrum may be very large and thick, so that upon recovery the entire shaft of the femur is greatly increased in diameter. Further, there may occur interference with the growth of the bone in case the epiphyseal cartilage is invaded. Pathological separation of the epiphysis may occur, with interference with the subsequent growth of the shaft, producing permanent shortening, if the disease occurs in children or during the period of growth, which indeed is the rule. In other cases the process will be of an irritating character, such that an overgrowth of the bone in length may take place, though the latter condition is less common than the former. If the entire thickness of the shaft over a considerable area undergoes necrosis, it will occasionally happen that not sufficient new bone is formed to preserve the continuity of the shaft, in which case very great shortening and deformity may result, rarely, with the production of an area in the thigh where no bone exists, and a flail-like limb.

Circumscribed osteomyelitis occasionally occurs in the femur, either as a secondary condition in the shaft, following the acute form, in cases in which the original operation has not removed all the infectious foci, or where they have formed in spite of such removal, and second, as a primary localized process in the epiphyses of the bone. In the case of the femur the latter group are more apt to occur in the lower than in the upper epiphysis. In both these groups the lesion is essentially a chronic one. The symptoms consist chiefly of pain and tenderness over the affected bone area. The constitutional symptoms are often slight or absent, but owing to the persistent pain, usually worse at night, these patients may suffer greatly from loss of sleep and deteriorate to a marked degree in general health.

The diagnosis is to be made from the history of a previous attack of acute osteomyelitis, or, in the group of cases primary in the epiphyseal end of the bone from the persistent pain and by the discovery of some point of extreme local tenderness over one or other condyle, upon pressure. Such a point of tenderness forms, as in the acute cases, a valuable guide for the position of an incision and for the point at which the bone should be opened. In these cases also the X-rays may be a valuable aid in diagnosis.

TUBERCULOUS OSTEOMYELITIS OF THE FEMUR

The pathology and course of the disease in general have been sufficiently described in Vol. I, page 188. Primary localization in the shaft of the femur is rare; much more commonly the infection occurs as an embolic process in the upper epiphysis, or in the neck, or in the lower epiphysis, in one or other of the condyles of the femur. The history of these cases is very generally that of tuberculous hip-joint disease, or of tuberculosis of the knee-joint, respectively. Only occasionally does it happen that the patient is brought to the surgeon at so early a period that the diagnosis of a localized tuberculous infection of the epiphyseal ends of the femur can be made at such a time that the operative

removal of the focus will prevent invasion of the hip- or knee-joints, respectively. It should be borne in mind in this connection, that, until the knee- or hip-joints are invaded, the local signs and symptoms referable to the presence of a tuberculous osteitis may be very slight indeed. In the condyles of the femur the child may complain of a little pain upon one or other side of the limb, and palpation may detect a small area of tenderness. Such children should be examined with care for evidences of tuberculosis elsewhere, and a family history of tuberculosis should be sought for. It is in these cases especially that carefully taken X-ray pictures with tubes of low resistance may enable the surgeon to locate the focus of infection before it has involved the joint, and thus permit its early and successful removal. I have in a number of instances been able to make the diagnosis of a small tuberculous focus in one or other condyle of the femur, or in the upper end of the tibia, and to remove it with preservation of the joint. In the upper end of the femur the conditions are much more difficult, unless the focus is situated in the great trochanter, when it may give rise to signs and symptoms sufficient for a diagnosis, or may be demonstrated by means of the X-rays. (See also Tuberculosis of the Hip. For further information see Vol. I, Tuberculosis of Bone, and The X-rays in Surgical Diagnosis.)

CHAPTER XXI

TUMORS AND DEFORMITIES OF THE THIGH

RACHITIC DEFORMITY OF THE FEMUR

For a general description of rachitis, see Vol. I. As has been stated in Vol. I, rachitis is a disease observed in children, due to improper feeding and unhygienic surroundings. The most notable results are disturbances in the nutrition of the bones. The bones are unduly pliable. This disturbance affects chiefly the development of the shafts of the long bones, due largely to imperfect activity of growth at the epiphyseal junctions. The diagnosis of these conditions usually presents no difficulties. In the femur a variety of deformities occur, among them coxa vara, elsewhere described, and in rachitic cases frequently bilateral. In the shaft of the bone the rachitic deformity is usually a bowing, with its convexity outward and forward. It is often associated with a similar deformity of the tibiæ, and in these cases very marked bow-legs are produced. (See Fig. 205.) Such anterior and outward bowing may be associated in the same case with coxa vara, and in a few cases which I have observed where the individuals went on to adult life without treatment, the improper manner in which the weight of the body was supported produced not only a painful affection of the hip-joint, but also a marked arthritis of the knee, with an overgrowth of the external condyle of the femur and partial pressure atrophy of the internal condyle. The coxa vara of rachitis is often due to an outward bowing of the upper part of the shaft; symptoms rarely appear until adolescence. In others the neck itself is bent downward.

A man who suffered from this condition, and upon whom I operated a number of years ago by dividing the shaft of the femur at the point of greatest convexity in its curve, was greatly improved thereby, although he never entirely recovered from the chronic arthritis of the knee-joint.

The deformities known as knock-knee, or genu valgum, and its opposite deformity, bow-legs, or genu varum, will be spoken of under "the knee-joint" and "the leg." In a general way, however, it may be said that the diagnosis of these conditions can be made on inspection.

We have already in various places described some of the congenital deformities of the femur under the head of Congenital Dislocation of the Hip-joint and Coxa Vara. In addition, there may be mentioned as rare congenital deformities an imperfect development of the shaft of the femur, such that the condyles below remain ununited to a more or less imperfectly developed

diaphysis, which in some cases is not united to the head or trochanter, so that the shaft being wholly or partly absent, the trochanter and head of the bone exist as independent centers of ossification. In a few cases the knee- and hip-joints are perfectly developed, and unite to a shaft which is greatly shortened and never develops sufficiently to be used properly in conjunction with the other limb. The details of these various deformities are readily recognized on inspection and palpation, and may be exhibited with great clearness by means of X-ray pictures.

FIG. 205.—MARKED RACHITIC DEFORMITY OF BOTH THIGH BONES AND OF BOTH LEGS. Genu varum. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

TUMORS OF THE THIGH

In the skin, in the soft parts of the thigh, and in the femur there may develop tumors of the most varied description. The diagnosis of the more superficial tumors is to be made from the diagnostic data of tumors in general. (See Vol. I.) In the femur, also, there occur a variety of tumor forms; the most interesting and important of these are the sarcomata. Their early diagnosis is highly important for their possessor, since only by early amputation, done best at the hip-joint, can even a remote hope of cure be obtained. See, however, below.

TUMORS OF THE SOFT PARTS OF THE THIGH

The upper third of the thigh and the groin furnish the largest number of tumors of the soft parts. In the skin and subcutaneous tissues of the thigh every variety of tumor may occur, both of the epithelial and connective-tissue types. One may enumerate lipoma and fibroma, with their combinations, angioma and lymphangioma, the latter sometimes combined with fibroma and with lipoma. Chondroma, myxoma, and, as stated in a preceding section, occasionally bony tumors, appear in the soft parts, the latter chiefly in the muscles. Carcinoma and sarcoma occur also in the soft parts of the thigh with considerable frequency. Cystic tumors of various sorts are also observed; among them atheromatous cysts, lymph cysts, dermoid cysts, and occasionally echinococcus. The characters of the lymphangiomata have been spoken of in a previous section. In the lymph nodes of the groin there occur also primarily

and secondarily sarcomata of various types. The cancerous lymphatic nodules of the groin secondary to cancer of the lower extremity, or to cancers situated in any of the regions drained by these lymph nodes, are usually easily recognized by the presence of a primary carcinoma, or a history of its removal. The secondary sarcomata of the lymph nodes are less frequent than the carcinomata, since, as was stated under Tumors, the sarcomata are more apt to spread through the blood current, the carcinomata through the lymphatics. Thus, one may see very large sarcomata of the femur with no involvement of the lymph nodes of the groin, whereas, after epithelioma of the penis, scrotum, or any portion of the lower extremity, the femoral and inguinal glands are often early involved. No special diagnostic data can be given in this place for the recognition of these different forms of new growth. The physical signs, the history, and the characters of the tumor, as determined by inspection and palpation, followed, if necessary, by an exploratory incision, are the diagnostic means at our disposal.

Sarcomata of Muscles.—The adductor region of the thigh is one of the favorite sites of sarcoma. The tumor is believed to develop, however, from the intermuscular planes rather than from the muscular fibers, or from the interstitial connective tissues of the muscles themselves. They may, however, develop not only in the adductors, but in the flexors and extensors of the limb. They are to be recognized here, as elsewhere, by their rapid growth, by the tendency to infiltration, and by the absence of the signs of an inflammatory process; yet it is to be borne in mind that some of these sarcomata grow with great rapidity, and may upon superficial examination be so soft as to resemble a diffuse inflammatory process. Here, as elsewhere, these rapidly growing forms may be accompanied by fever. Physically they may show every variety of softness or hardness, according to their structure. (See Vol. I, Sarcoma.)

The prognosis of the more malignant types of sarcoma of the muscles of the thigh is as bad as that of these tumors in other parts. Recurrence may, however, be long delayed. I removed, some years ago, a large sarcoma of the round- and spindle-celled type from the groin of a young girl. The tumor was the size of a child's head at term, and involved the adductors in the upper part of the thigh. Although the tumor mass had involved several of the adductor muscles, yet it was not a diffuse growth, but seemed to possess a kind of capsule. No recurrence took place for seven years, when the patient, who had then grown to be a woman, died of sarcoma of the lung.

The malignancy of the different forms seems to vary greatly in different cases, even though the tumors under the microscope may show identical histological characters. Thus, two years ago I operated upon a woman, aged thirty-six, for a large mass of sarcomatous nodules, which occupied the groin, the anterior abdominal wall, and the retroperitoneal glands of the lumbar region. The tumors were of the spindle-celled type of sarcoma. The patient recovered from the operation, but died about a year and a half later of internal recurrences. The interesting feature of the case was, that since this woman

was a child of five years, she had had fifteen operations for sarcomata in various parts of the body, which had always recurred, either locally or in some distant part, as often as removed. I had operated upon her three years before the last operation for an enormous sarcoma occupying the lumbar region and extending forward and downward below the crest of the ilium. In spite of these numerous operations, she had grown up to be a strong, robust, and vigorous-looking individual, had married, and had had children. In this case the malignancy was of a character such that recurrence invariably took place after operation, but in which the invasion of important structures with a fatal result did not occur for many years.

One sees also sarcomata of other regions which show these peculiar characters, and where rarely after repeated operations the tumor appears at each recurrence to be slightly less malignant. Thus I recall a case of sarcoma of the upper jaw of the giant-celled type which was operated upon in the Roosevelt Hospital by Dr. Charles McBurney five times, and subsequently by myself. After the last operation the patient remained free from recurrence for a period of nearly five years, when I lost sight of him.

Neuroma.—The nerves of the thigh, especially the superficial cutaneous nerves, are not infrequently the sites of the development of neurofibroma. These tumors, as elsewhere described, form small, rounded, or spindle-shaped nodules in the course of a cutaneous nerve. They may be the size of a pea, seldom as large as an almond. They may give symptoms of pain and tenderness, or of paresthesiæ, in the distribution of the nerve, or, on the other hand, may be quite painless. They are not infrequently multiple (hundreds have been observed in the same individual), and may then constitute, if painful, the so-called *tubercula dolorosa*. The apparently innocent neurofibromata may, in some instances, suddenly take on a rapidity of growth and become malignant sarcomata.

The **plexiform neuromata** are not very rarely observed in the thigh. They also show a rather strong tendency to myxomatous and rarely sarcomatous degeneration, and, as was stated when describing these tumors in the upper extremity, tend to spread up and down the length of the nerve and to involve other trunks. In these cases multiple nodules will be found in the course of the nerves, and the nerve trunks themselves may be apparent on palpation as cords of considerable size. They are usually painful spontaneously and upon pressure. In some cases the plexiform neuromata remain benign, and though they may involve many nerve trunks and be spread over a large area, they do not destroy life, and may after a time cease to grow.

The amputation stumps of the leg and thigh are favorite sites for the development of fibroneuromata. Such tumors upon the end of a stump may be exceedingly painful and annoying, so that the individual may be unable to wear an artificial limb. In some cases a true ascending neuritis develops in the affected nerves, so that while in the majority of instances incision and the removal of the enlarged nerve end will cure the painful condition,

in others the pain still continues, even after the tumor has been removed. It is customary at the present time, when making amputations of the extremities, to excise the larger nerve trunks some distance above the level of the amputation wound. Starr says in this connection: [1]

In one patient under my observation who suffered from great pain referred to the toes, for many years after an amputation of the leg above the knee, excision of the neuroma on the sciatic failed to give relief. A portion of the sciatic nerve in the thigh was then excised, but this also failed to stop pain. In this case it seemed probable that atrophic changes had occurred in the spinal cord, such as are known to follow amputations, and that these had involved not only the anterior horns, but also the sensory columns.

In regard to the extirpation of the neuromata of the benign type, it may be said, as when speaking of similar tumors of the upper extremity, that the operative removal of these fibro-neuromata may sometimes be made without injury to the nerve trunk upon which they grow. In other cases the nerve is so incorporated in the tumor mass that the extirpation of the latter without destruction of the nerve is impossible. In these, the amount of pain, and the character of the disturbance of function likely to follow the excision of the nerve must be taken into account in deciding whether the tumor should be removed or not. If the nerve is resected it should at once be united by suture.

Tumors of the Femur

Benign Tumors.—A variety of benign and malignant new growths may develop upon the femur. Among the former may be mentioned the *fibrocystic enchondromata.* These tumors occur in the majority of instances in young people and grow from the upper part of the bone, usually just below the great trochanter. They are of rare occurrence. They are tumors of slow growth and distinctly benign, and yet may produce great deformity, disability, and even necessitate amputation of the extremity, since, after they have grown to a certain size, they may so far destroy the continuity of the bone as to produce spontaneous fracture and possibly necessitate amputation. In other cases, while spontaneous fracture does not occur, the bone is softened and its strength so impaired that curvature of the upper portion of the femur takes place, and marked deformity, with loss or impairment of function. These tumors consist of a framework of fibro-cartilage containing bony lamellæ, inclosing large cystic cavities, which frequently involve both cortical and medullary portions of the femur. While they grow slowly, they may in certain instances attain a very great size indeed, and produce an enormous spina ventosa of the upper portion of the femur with parchmentlike crackling on palpation. The recognition of the exact character of the growth can be made partly from the history of its very slow progress, in that way differing from the sarcomata of the femur by the

[1] Starr, *loc. cit.*, p. 77.

absence of metastases, and by the use of the X-rays, although the picture would probably not materially differ from that of a large osteosarcoma. The treatment of the tumors is extirpation, if possible, with preservation of the shaft. If seen after deformity of the femur has already occurred, a good result may sometimes be obtained by excision of the portion of bone the seat of the tumor, and attempting to get union between the fragments of the shaft. The decision as to the character of the operation would depend to some extent upon the area of the bone involved.

FIG. 206.—BONY TUMOR ON THE ANTERIOR SURFACE OF THE SHAFT OF THE FEMUR. The tumor produced no symptoms and was let alone. (Author's collection.)

Simple enchondromata, and combinations of enchondroma with osteoma are observed in the femur, sometimes as isolated growths, and sometimes as tumors with multiple localizations. They are sometimes developed in connection with the diaphysis of the bone, but more frequently occur near the junction of the shaft with the lower epiphysis. They are tumors of slow growth, and if they produce symptoms at all, do so mechanically by pressure upon nerves or blood-vessels, or possibly by causing pain when certain muscles are pressed upon by the tumor during contraction. The character of these new growths can usually be easily recognized. They are hard, firmly attached to the bone, painless, and insensitive, and of a smooth or knobby and irregular contour. In the case (Fig. 206) shown in the text, an osteochondroma of the shaft of the femur, the patient, a woman of forty-five, had noticed the presence of a hard lump in her thigh for many years. It had given rise to no symptoms and I did not recommend its removal. Occasionally, as the result of *trauma and irritation of the periosteum*, a bony growth may occur in connection with the shaft of the femur.

Such tumors have been described growing from the region of the *linea aspera* as the result of trauma, of considerable size, as large as a fist or even as the head of an infant at term.

Fibromata, fibromyxomata, and very rarely *pure myxomata,* have been described as originating in the femur, as well as a very few cases of lipoma. The last has occurred as a congenital tumor in the region of the lesser trochanter.

Sarcoma of the Femur.—The most frequent, as well as the most important, tumors of the femur are the sarcomata. They may originate here, as in other long bones, from the medulla, or from the periosteum. The medullary sarcomata originate in the epiphyses more often than in the shaft, and more frequently in the lower than in the upper end of the bone. The periosteal sarcomata originate usually from the shaft rather than from either epiphysis. Of the central sarcomata it may be said that the several types of sarcoma are all observed—round-celled, spindle-celled, mixed-celled, and giant-celled forms. The giant-celled sarcomata grow most frequently in the lower end of the femur, and are believed to be somewhat less malignant than the other types. Inasmuch as the central sarcomata of the lower epiphysis cause an enlargement of the bone in the vicinity of the knee-joint, they are sometimes mistaken for tuberculous disease of the knee. In some of the cases the functions of the knee-joint are preserved until late in the disease; in others, irritation of the joint with a serous effusion into the synovial sac may occur. An error in diagnosis—namely, confounding sarcoma with tuberculosis of the knee—ought not to occur, because, as stated, in many instances the function of the joint is preserved and in those giving symptoms of joint irritation the lower end of the bone will almost always show evidences of great enlargement. In cases of doubt the X-rays will sometimes show the bony dilatation and bony destruction of the deeper portions of the bone. A positive finding by this method is, however, by no means constant, and those who have given much attention to this method of diagnosis in sarcoma of the femur doubt whether its value in the early stages of the disease is very great. (Coley, Butlin.)

One of the signs which suggests at once the probable presence of malignant disease, is dilatation of the superficial veins in the vicinity of the knee and lower portion of the thigh, but this is not present at a time while the prognosis is hopeful. The periosteal sarcomata cause an enlargement of the bone, though the consistence of the tumor will vary greatly. In the early stages the tumor may be quite hard, though after it has grown larger, notably if it be of the round-celled variety, it may be extremely soft, even fluctuating. In some cases the consistence of the tumor will vary in different parts and in these, hard areas may alternate with those which are soft, or even fluctuating, and if the tumor is of central origin, the sensation of bony crackling may be appreciated. In the softer and more vascular forms the tumor may exhibi' pulsation and might, if it occur in the popliteal space, be mistaken for aneurism In a fairly large proportion of cases a spontaneous fracture of the bone ma early occur and may be the first sign of the gravity of the condition. Tl

amount of *pain* felt in sarcoma of the femur has nothing characteristic about it. In many cases during the early stages of the disease pain is slight or absent and may not be severe until quite late. In several cases which I have observed of sarcoma of the long bones, humerus and femur, the patients have been treated during the early stages for rheumatism, and this is, I believe, a frequent diagnosis. Gross stated that pain occurred as an early symptom in sixty-two per cent of the cases, and that in thirty-three per cent a tumor was first noticed. It is to be borne in mind also in relation to sarcoma that an injury has preceded in a considerable proportion of cases, variously estimated at from one third to one half. As stated, the disease for which sarcoma of the lower end of the femur is most often mistaken is *tuberculosis*. To recapitulate: In regard to the central sarcomata, both conditions are apt to occur early in life, though tuberculosis occurs on the average at an earlier period than sarcoma. In both conditions there may be an evening rise of temperature. Involvement of the knee-joint is rather rare in sarcoma during its early stages. It is regarded as an important diagnostic difference between tumor formation of the femur and tuberculosis. The swelling in tuberculosis involves as its center the joint. In sarcoma the tumor is apt to be less symmetrical, appearing more prominent upon one or other surface of the bone. The amount of muscular atrophy is much more marked in tuberculosis than in sarcoma. The differential diagnosis of sarcoma from *syphilis* of the femur can usually be made. In most instances of syphilis there will be a history of infection and in many cases other evidences of active disease, or the scars of former syphilitic ulcerations. The syphilitic enlargements of the femur are rather more apt to involve the middle portion of the shaft than sarcoma, and the progress of the disease is slower than the average case than sarcoma, very much slower than the more rapidly growing forms. In cases of doubt active antisyphilitic treatment is useful in the diagnosis. The Wasserman reaction may aid. (See Appendix.)

Arthritis deformans of the knee has occasionally been mistaken for malignant disease, but in the former condition the X-rays will show the characteristic bone changes; the joint itself is distinctly the seat of the lesion and other joints are frequently involved.

The *periosteal sarcomata* develop in the shaft of the bone more often near the lower end than elsewhere. When situated in the femur they are as malignant and deadly as any form of tumor. The various forms of sarcoma occur here—round-celled, spindle-shaped, giant-celled, and mixed forms, together with combinations of fibroma and sarcoma. The last are less malignant, they are rather slowly growing, and do not show the same tendency to rapid infiltration and destruction of the surrounding soft parts, nor to the formation of early metastases that are observed among the more malignant forms. The most malignant form here, as elsewhere, is the round-celled sarcoma. The spindle-celled, giant-celled and mixed-celled forms lie between the round-celled and fibro-sarcomata in malignancy.

The signs and symptoms of periosteal sarcoma of the femur are, to recapitu-

late them briefly, an enlargement of the bone, sometimes sharply circumscribed, in others more diffuse, with the production of a spindle-shaped tumor. Spontaneous fracture is sometimes an early sign of the destructive process. The formation of spina ventosa with bony crackling, later with widespread infiltration of the soft parts and dilatation of the superficial veins are common. Metastasis occurs, as a rule, through the blood-vessels rather than through the lymphatics, so that the tumor may have reached a very large size and yet no involvement of the lymph nodes of the groin may be present.

The commonly accepted treatment of the more malignant forms of sarcoma of the femur is disarticulation at the hip-joint. Some of the fibro-sarcomata have been cured by removal of the tumor without amputation and without resection of the femur. Other cases have been cured by the removal of the growth, including a portion of the shaft of the bone. My own opinion is in favor of early disarticulation at the hip, if the diagnosis can be made before the disease is far advanced and before metastases have occurred.

The *prognosis* of sarcoma of the femur is very unfavorable. Among all the cases of sarcoma of the femur treated by disarticulation at the hip-joint in the Roosevelt Hospital between the years 1889 and 1899, about ten in number, none, so far as I am aware, were cured. One case operated upon by Dr. Frank Hartley, a mixed-celled periosteal sarcoma of the shaft, was amputated below the trochanter minor. He survived for six years without recurrence, when he was lost sight of. The statistics of Dr. A. J. McCosh are the most encouraging I have seen. He treated seven cases of sarcoma of the femur, six by disarticulation at the hip-joint and one by amputation below the trochanter. In the former group one patient was well at the end of twelve years, one patient was well at the end of five and a half years, one patient was well at the end of four and a half years; the other cases died of recurrences. W. B. Coley [1] treated six cases of sarcoma of the femur by hip-joint amputation. All survived the operation, but subsequently died of recurrences. In his observations upon his own and the cases of others, he found that there was little difference in the malignancy, whether the tumor began in the periosteum or medulla. He further states that of ten cases treated by high amputation below the trochanter, one died two years later, one died four months later, a third died seven months later, a fourth died six months later; all with metastases. Six cases remained which immediately after amputation or as soon as practicable were treated by the injection of the mixed toxins of erysipelas and the Bacillus prodigiosus. All these cases remained well for variable periods. In three, however, recurrence took place. Coley also relates the histories of two cases of sarcoma of the femur in which no operation was performed. One of these was a round-celled sarcoma of the upper part of the femur in a girl aged nineteen. Her condition was too far advanced for operation; she suffered a spontaneous fracture of the femur. Treatment with the toxins was followed by disappearance of the tumors and

[1] W. B. Coley, *Surg. Gynec. and Obstet.*, February, 1908, pp. 129–144.

by union of the bone. She was well four years after treatment. A second case was a youth nineteen with a round-celled subperiosteal sarcoma of the femur involving the lower two thirds. The diagnosis of the condition was made by an exploratory incision and microscopic examination. This patient refused operation. He was treated by injections of the toxins, and some of the metastatic tumors broke down and were incised. Under the treatment, however, the patient finally recovered, and Dr. Coley informs me he is now well. He first came under treatment in February, 1902.

Another peculiar tumor has sometimes been observed in the femur, as was mentioned under Tumors of the Thyroid Gland—namely, carcinoma of the thyroid may give rise to bone metastases, and these latter may have the histological structure of carcinoma, or, may exhibit the structure of apparently normal thyroid tissue. Such tumors have given rise to spontaneous fracture. The metastases of *hypernephroma* in the bones have been mentioned under tumors of the kidney.

Carcinoma.—Primary carcinoma of the femur does not occur, but metastases from carcinoma primary in other parts of the body with localization in the femur are by no means rare. Such may occur after carcinoma of the breast, carcinoma of the prostate, carcinoma of the uterus, and in conjunction with other localizations. The signs and symptoms are very frequently those of spontaneous fracture, followed by rapid invasion of the surrounding soft parts. (For a picture of a case of this kind see Fig. 96, page 261, Vol. I.)

Echinococcus.—Echinococcus of the femur has been observed either as a distinctly localized tumor, consisting of large cysts, or as a more or less diffuse process of a multilocular character. (See Echinococcus.) In the first form the disease is of slow growth, and in the observed cases the increase in size has not been continuous, but has been characterized by periods of rapid growth, followed by longer or shorter stationary intervals. The bone is enlarged, and the cancellous tissue destroyed with irritation of the periosteum and expansion of the cortical layers. Spontaneous fracture may occur. The diagnosis is not very apt to be made until the time of operation. In the diffuse form of echinococcus, the entire shaft of the bone may be occupied by numerous small cysts and the intervening bone is more or less completely destroyed. In these cases an operation similar to that done for acute osteomyelitis might be practiced with preservation of the continuity of the shaft.

CHAPTER XXII

INJURIES OF THE KNEE

THE knee-joint, the largest in the body and one of the most complicated, is, from its exposed position, subjected to injuries from direct external violence with great frequency, as well as to a variety of strains from falls, blows, and from muscular action. The joint is a very superficial one, readily injured, and reacts promptly and often violently when any of its essential structures are wounded.

CONTUSIONS AND SPRAINS OF THE KNEE AND THE NEIGHBORING STRUCTURES

Contusions of the soft parts overlying the knee-joint occur with great frequency, and so long as the extra-articular structures merely are bruised the injuries are without serious significance. Superficial contusions may be accompanied by abrasions and be followed by ecchymosis, or by the formation of a subcutaneous hematoma. The abrasions are recognizable on inspection and require no special comment. Ecchymosis is readily visible upon exposing the naked limb. The formation of a circumscribed hematoma, as the result of falls and blows upon the knee, is infrequent, since the structure of the subcutaneous tissues is so loose that the blood rapidly finds its way up and down the limb and causes no circumscribed swelling. If, on the other hand, one of the *bursæ* is severely bruised, the prepatellar bursa or the bursa beneath the patellar tendon, blood may be extravasated into the bursal cavity with the formation of a more or less rounded, circumscribed, elastic lump at the site of the bursa. Recognition of the condition is sufficiently simple upon inspection and palpation, the lesion is of no great importance so long as the effused blood does not become infected. When the blood remains within the bursa, it is but slowly absorbed and may remain as a moderately tense and elastic swelling for many weeks.

Occasionally such an inquiry will give rise to a chronic inflammation of the bursa. If the bursa be ruptured the blood will find its way into the surrounding tissues and be rapidly absorbed. The diagnosis of the character of the effusion into the bursa may be rendered positive by the use of an aspirating needle. A single traumatism of this kind is usually recovered from completely, though in a few instances it becomes chronic. Repeated traumatisms will lead

to a chronic inflammation of the bursa, usually the one in front of the patella, less commonly the bursa beneath the patellar tendon. The former condition is known as " housemaid's " knee, and will be elsewhere described. The latter —namely, chronic inflammation of the bursa between the ligamentum patellæ and the tibia—sometimes runs a peculiar course, in that the bursa remains enlarged and the irritation is perhaps kept up by pressure of the overlying tendon. In these cases there is not infrequently formed in the wall of the bursa nodules and plaques of cartilage, which may undergo ossification, constituting the condition known as "*exostosis bursata.*" The condition will be more particularly described in another section.

In regard to contusions and abrasions of the knee attended by marked extravasation of blood beneath the skin, it is to be borne in mind that abrasions may furnish an avenue for the entrance of pyogenic microbes to the subcutaneous tissues with infection and a more or less serious inflammation, which may take on a phlegmonous character. It is further to be recalled that the knees of persons not addicted to frequent bathing are unclean, and that the skin is often infested with pyogenic organisms of a more virulent character than are to be found among those who bathe frequently, so that, in this group of cases, the microbes in the abraded and contused skin may also cause infection of the deeper structures. A thorough disinfection of the knee, lower thigh, and upper leg, therefore, with the subsequent application of an aseptic dressing, is always a wise precaution in severe contusions of this region.

The presence of *infection* in contusions about the knee-joint is readily recognized by the presence of swelling, pain, heat, redness, and tenderness, together with constitutional symptoms and inflammatory leucocytosis. An aspirating needle will readily establish the character of the underlying broken-down blood clot, and if such be evidently infected, proper incisions are required for drainage. The characters of the acute phlegmonous processes of the skin and subcutaneous tissues of the thigh do not differ from those observed in the upper extremity and have been sufficiently described in Vol. I.

The contusions of the knee which involve the joint structures themselves are of far more serious moment than those just described. As a general rule the injuries of the knee-joint thus produced are partly the result of contusion and partly of distortion of the joint, or, as it is sometimes called, a sprain, involving an injury, sometimes chiefly of the synovial membrane, sometimes chiefly of the ligamentous structures, with stretching and partial rupture of the latter. Such accidents may happen from falls or blows upon the knee, but much more frequently they occur as the result of sudden forced movements, which put the ligaments unduly upon the stretch. The most frequent cause of a sprain of the knee-joint is when an individual stands with his knee slightly flexed, and a sudden force acts to abduct the knee upon the thigh. Such accidents frequently happen to men who play lawn tennis, football, or who engage in violent athletic sports of any kind, and they are common enough as the result of mis-

steps, slipping while walking, or they may even occur from very slight degrees of violence indeed, such as a sudden rotation of the body while the individual is bearing his weight upon one leg, thus putting the internal lateral ligament of the knee-joint upon the stretch. The results of these accidents vary greatly in severity, and are expressed in all cases by a group of signs and symptoms which indicate irritation of the knee-joint and are accompanied by an effusion into the joint cavity, sometimes of blood from the ruptured vessels of the synovial membrane, and sometimes of serous fluid, though in the former group a bloody exudate is followed by a serous one later on. We shall attempt to describe the simpler cases first, and later on those of a more serious character, some of which do not tend to get well themselves, and constitute a group of lesions which, if not treated or improperly treated, impair the integrity of the joint.

In the cases attended by a more or less extensive rupture of the ligaments, or of the synovial membrane, hemorrhage occurs into the joint in greater or less amount (hemarthros). After fairly severe injuries, the amount of such hemorrhage is apt to be large, although considerable bleeding into the joint may occur, though the traumatism has apparently been slight. The blood thus effused into the joint remains fluid for days and even weeks, unless there has been a fairly extensive laceration of the ligaments, or a fracture, as, for example, of the patella. To the bloody exudate there is soon added, as an expression of the irritation, a pouring out of synovial fluid in greater or less amount. If the injury has been quite severe and a considerable laceration of the joint structures has occurred, the blood will usually clot at an early period. When operating upon fractures of the patella a week after the original injury, the blood is usually found in a clotted condition. From a practical point of view this is sometimes important, since, as was pointed out in Vol. I, fluid blood may readily be made to pass through an aspirating needle; not so clotted blood. The evacuating of clotted blood requires either an incision or the introduction into the joint of a trocar of considerable size and the application to it of powerful suction, or irrigation of the joint with salt or other solution.

The *symptoms* of a sprain or severe contusion of the joint are immediate, sudden, sharp, severe pain referred to the seat of the injury, after which the patient may or may not immediately be able to use the limb. Usually after minutes or an hour has elapsed, he will be able to walk, although with considerable pain. If the hemorrhage into the joint is considerable, there will occur, with greater or less rapidity, a swelling, and distention of the joint capsule with blood, and such distention may be extreme and accompanied by very severe pain. The sooner after the injury and the more rapidly the joint fills, the more probable it becomes that the effusion consists of blood. If, on the other hand, the bleeding has been slight, the patient may suffer comparatively little inconvenience for twelve or more hours, when the symptoms of an acute serous synovitis will rapidly develop. Again, the joint will become swollen and distended with fluid. When the injury has been due to stretching or tearing of

the ligamentous structures, there will be no evidences of contusion in the vicinity of the knee, but there is often very marked ecchymosis developed in the course of a day or two. After the effusion, whether bloody or serous, has distended the joint capsule, the patient will suffer pain, spontaneous, or, on using the limb or both, of greater or less severity. The larger the effusion, the greater the pain.

The signs and symptoms of acute synovitis of the knee are characteristic and easily recognized. The normal depressions upon either side of the patella disappear and give place to protrusions. That portion of the synovial sac which lies upon the front of the thigh above the patella becomes distended and forms a marked, rounded prominence on the front of the limb. The patella is lifted away from the condyles of the femur and the sign known as "floating patella" is observed. For the details of the examination for this sign see Vol. I, page 160, to which the reader is referred. If the effusion is considerable, the signs of elastic tension—i. e., fluctuation—are readily elicited on palpating the quadriceps bursa of the knee. Assuming that the effusion is largely composed of blood, such blood, so long as it remains fluid, will give the ordinary signs peculiar to fluid accumulations. When, however, the blood has clotted, instead of the sensation of elastic tension such as is given by fluid in the joint, the distended sac may feel of a doughy consistence. Further, the sign of the floating patella may be difficult to elicit, or may not be appreciated at all. Upon further manipulation, there may be detected the peculiar soft crepitation characteristic of clotted blood contained in a cavity. It is hard to describe, but very readily recognized when present. It has been likened to the crunching of soft snow when squeezed in the hand. The amount of disturbance of function and pain in these cases will depend, in the first place, upon the severity of the injury to the joint structures, the amount of contusion and laceration of the ligaments and of the synovial membrane, and, second, upon the degree of distention of the joint. If the injury is comparatively slight, these patients may even walk about for a number of days before they come to the surgeon for advice, in the meantime suffering only a slight amount of pain and disability, and some sensation of weakness in the knee. They may even discover only accidentally that the knee is swollen. In more severe cases, on the other hand, the patient will suffer so much pain that he is disinclined to use the limb, and holds it quietly in a position of slight flexion. If the effusion into the joint is excessive, the distention will cause extremely severe pain.

The constitutional symptoms accompanying acute traumatic synovitis of the knee are, a a rule, trifling, assuming, of course, that no open wound exists and no infection occurs. It will not always be possible during the early days following such an injury to say whether the patient will recover rapidly and completely, or whether, on the other hand, a somewhat serious injury has occurred. The distortions of the knee-joint attended by fracture or dislocation of the semilunar cartilages, ruptures of ligaments, etc., will be described in a subsequent section.

In the simple cases of traumatic synovitis, rest, the application of cold to the joint, pressure, massage, and immobilization will usually cause the effusion to be absorbed in the course of from ten days to three weeks. If the effusion, however, consists largely of blood, this absorption may require a much longer period, and the function of the joint may not be perfectly regained for a number of months. Apparently the presence of a considerable quantity of blood in the joint tends to the production of adhesions between the folds of synovial membrane with limitation of motion of a more or less marked degree. On this account many surgeons recommend very early active and passive motion in such joints. During recent years experience has shown that in these cases early aseptic incision of the joint, or the introduction of a trocar followed by irrigation of the joint cavity, thus removing all the blood, tends greatly to shorten the period of convalescence. In a certain proportion of cases, even among healthy individuals, these apparently simple injuries of the knee may be followed by a chronic or a relapsing serous synovitis of indefinite duration. The pathology of these conditions is spoken of in a subsequent section. The treatment of acute traumatic serous synovitis, if the effusion consists chiefly of synovia with but little blood, is rest and immobilization of the limb, with the knee very slightly flexed and placed upon a posterior splint, well padded in the popliteal space; in addition, cold in the form of an ice-bag, and pressure by means of an elastic bandage, or an ordinary bandage padded with cotton. As soon as the acute symptoms have subsided—namely, after a week—and the effusion has diminished in amount, these cases are best treated, in my experience, by massage, and the application of a light, removable, plaster-of-Paris splint in which the patient is permitted to walk about. The plaster is kept on until the effusion has entirely disappeared, when he may be permitted to resume the active use of the limb. If the functions of the joint are not speedily and completely regained, active motion, massage, baking, douching, and the like will usually affect a cure. Another plan of treatment is to keep the limb quiet for a few days as before, and with similar measures, but to begin massage, douching, and moderate use of the limb at a very early period. It is believed by many surgeons that by this form of treatment the joint is more readily restored to its free normal function. It is a plan better suited to men who desire to lead a very active life and are unwilling to lie up, than to ordinary individuals, since it is accompanied by a considerable amount of pain and discomfort.

FIG. 207.—ACUTE TRAUMATIC SYNOVITIS OF THE KNEE-JOINT.

INTERNAL DERANGEMENT OF THE KNEE-JOINT

Dislocation and Fracture of the Semilunar Cartilages; Avulsion of the Crucial Ligaments from the Femur, the Infra- and Suprapatellar Pads

It should be understood that the terms acute serous synovitis of the knee-joint and hemarthros of the knee, as described in the preceding section, are used simply to designate a clinical picture without explaining the actual pathological lesion of the joint. In a large proportion of these cases we do not know what the actual lesion is, since the individuals recover completely under conservative treatment. In another and fairly large group of cases the injury is followed by the symptoms described in the preceding section, but the patient does not completely recover and is left with a joint weakened in certain directions, liable to recurring attacks of synovitis upon immoderate use of the joint, or upon slight traumatisms. In a certain proportion of cases these injuries may be followed by a chronic condition which, if neglected, may lead to very serious impairment of the functions of the knee and even the production of chronic invalidism and serious lameness, and in the worst cases to a chronic arthritis of a painful and even destructive character. B. Tenney wrote a very complete monograph on this topic, published in the *Annals of Surgery*, July, 1904, based upon dissections of 150 knee-joints, upon his own clinical experience and the published literature. His conclusions in regard to the motions of the knee and of the ligaments restraining such motions are as follows:

The fully extended joint is without lateral motion, antero-posterior motion, or rotation. All three movements are present to some degree after slight flexion and increase up to right-angled flexion, after which they diminish again.

Extension is limited first by the posterior crucial. After rupture or section of this ligament, extension is still further increased by rupture or section of the anterior crucial, and later after rupture of the internal lateral and external lateral ligaments.

The oblique or posterior ligament of Winslow resists this motion little if any. Flexion is limited by the contact of the soft parts.

External rotation is limited by the two lateral ligaments and increased after section or rupture of either.

Internal rotation is limited by the internal lateral and anterior crucial in combination, and increased after section or rupture of either.

A slight forward slipping of the tibia on the femur is possible in external rotation, but is stopped first by the anterior crucial, and later by the two lateral ligaments. A slight backward slipping of the tibia on the femur is also possible on external rotation, but is limited first by the posterior crucial and later by the two lateral ligaments. Adduction and abduction are also possible in external rotation to a degree which can be felt with the hand on the joint. Adduction is limited first by the external lateral ligament, and later by the posterior crucial. It is also increased on the cadaver after removal of the internal semilunar. Abduction is limited first by the internal lateral, and later by the posterior crucial. On the cadaver abduction is greater after removal of the external semilunar.

Among the internal derangements of the knee-joint observed by Tenney in the 150 specimens examined, the following types were found, arranged according to their frequency:

1. Tabs from the lubricating apparatus.
2. Erosion of cartilage.
3. Damaged and displaced semilunar cartilages.
4. Ruptured ligaments.
5. Free and loose bodies.

He also mentioned, though it did not occur among his cases, a villous or papillary synovitis. Tenney found that what appeared to him to be the most frequently injured structure in the joints examined, was the infrapatellar pad, and he believed that the changes observed were due to the fact that the pad might be caught during flexion between the patellar and the femur, or between the femur and the tibia. Tenney states that there are but few references in recent literature to the operation for the removal of fatty and fibrous tabs as such.

Some, reported as growths from the synovial membrane above the patella, were possibly tabs from the suprapatellar pad. Others, described as fringes of the ligamenta alaria, are evidently tabs from the infrapatellar pad.

In a considerable proportion of the cases examined, Tenney found erosion of the cartilage at the back of the upper surface of the external tibial tuberosity. Such erosion varied from slight cracking or roughening to complete erosion with exposure of the bone. Under the head of damaged and displaced semilunar cartilages he found that both the internal and external semilunars showed evidences of injury from being crushed, or torn, or worn away in a fairly large proportion of the cases examined.

In 15 cases both cartilages showed one or other of these changes. In 13 the changes were confined to the external semilunar. In 14 the internal semilunar was damaged, while the external was normal. There were 29 cases in which the internal semilunar showed evidences of injury and 28 cases in which some evidences were found in the external semilunar. In 24 of the cases there were in addition evidences of a more or less marked chronic arthritis in the joint.

From his experiments and those of others, Tenney concludes that the ligaments may be ruptured as follows:

Internal lateral ligaments by abduction and external rotation. Anterior crucial by internal rotation and forward slip of tibia on femur. Posterior crucial by internal rotation, extension, and backward slip of tibia on femur.

Tenney believed that as the result of these ruptures increased movements between tibia and femur occur such that the semilunars were exposed to frequent slight traumatism, so that the cartilages were roughened, fringed, or worn

away, and that thus more or less marked disturbance in the function of the joint might occur.

A moderate number of cases are recorded in the literature of rupture of the crucial ligaments. In ruptures of the lateral ligaments of the joint the injury would of necessity be severe and would be attended by marked disability, usually by hemorrhage into the joint, and the end results, if not treated by suture, are known to be, as the result of experience, not infrequently a permanent relaxation of the joint with increased movement and a strong tendency to the production of chronic or recurring synovitis, sometimes of arthritis deformans. In a subsequent article in the *Annals of Surgery*, November, 1908, page 714 ("Some Surgical Conditions in the Knee-joint," by Benjamin Tenney), Tenney describes certain chronic painful affections of the knee-joint, which he believes to be due to hypertrophy of the infra- and suprapatellar pads and to the traumatism to which such pads are exposed by being caught between the patella and the femur, or the femur and the tibia. He says that these cases occur in two types. In the first group the patients are usually fat women who find that upon walking, or going upstairs and downstairs, they suffer from pain in the knee-joints, and he states that if these patients can be reduced in flesh by feeding, exercise, the use of thyroid extract, or other means, the joint disturbances will be improved or cured.

In a second group of cases the patients are young persons in good health and frequently athletes. These patients suffer from recurring attacks of synovitis of the knee-joint and are conscious of something catching at times in the knee, notably when going downstairs, and that in some of the cases passive flexion of the joint with pressure on the pad and patella produces a characteristic slight snap. The operative removal of these pads has been followed in his hands by excellent results.

The diagnosis of injury to the lateral ligaments of the joint short of dislocation is to be made from the occurrence of an accident such as will produce abduction and outward rotation of the limb with injury to the internal lateral ligament, or adduction with internal rotation, producing injury of the external lateral ligament, the latter condition being more rare. The violence in these cases will usually have been considerable. The patient will suffer from severe pain at the site of the torn ligament with marked tenderness on pressure over its points of attachment to the femur and tibia, respectively. There will be, in addition, increased lateral mobility in the joint and the signs of an acute traumatic synovitis, frequently of hemarthros. Tenney states that:

> If the injury to the ligament be fresh and severe enough to increase the lateral and torsion movements decidedly, I fully believe that the obligation to open and repair damage is greater than with fractured patella. In both cases there is blood in the joint cavity which will favor adhesions, and in both cases the torn surfaces are separated by blood clot and ragged weak tissue. Nature's coaptation and repair of a ruptured lateral ligament is likely to leave the patient more of a cripple than the longest sort of a "fibrous union" patella.

Tenney further states that, where he has been able to make the diagnosis of ruptured lateral ligaments and where the patients were treated by conservative means, the individuals were apparently more or less permanently crippled.

Dislocation and fracture of the semilunar cartilages are not very rare injuries, and are attended, as a rule, by quite definite symptoms. The violence is usually slight and most commonly consists of a sudden abduction with outward rotation of the knee, when it is slightly flexed. The characteristic symptom is that the patient suddenly finds his knee-joint locked in partial flexion, the cartilage having become engaged between the femur and the tibia. The patient at the same time suffers more or less pain; he is unable to bring his heel to the ground. As the result of manipulation, usually gradual extension, followed by sudden flexion, the cartilage slips back into place and the symptoms are for the time over. In some of the cases the border of the cartilage may be felt projecting at the front of the joint; and by moving the joint back and forth and pressing upon the cartilage, it may be replaced. The internal cartilage is much more often injured than the external. The nature of the injury varies in different cases. The cartilage may be torn away from its tibial attachment and displaced backward in the joint, even so far as to lie in the intercondylar notch. In other cases the cartilage is fractured. In two of my own the internal semilunar was torn completely away from its anterior tibial attachment. In a third there was a loose fragment of cartilage which had been torn away from the free border of the semilunar and lay free in the joint. In another case the cartilage was split into two pieces at the junction of its anterior with its posterior two thirds. I have operated upon five of these cases and in each have removed the injured cartilage. In all, a recovery from the attacks of synovitis, which had disabled the patients for periods varying from six months to three years, occurred, and in all a perfect functional result followed. One of the patients was a member of the Fire Department in the City of New York and was able to return to his work. Another is at present with Peary somewhere in the vicinity of the North Pole. This last case was an athletic young man who was able, six months after the operation, to play football and to engage in cross-country running, etc.[1]

The *diagnosis* of dislocations and fractures of the semilunar cartilages is usually simple, from the characteristic history of the locking of the joint and the recurrent attacks of synovitis, sometimes by the possibility of feeling the edge of the displaced cartilage. The symptoms are, however, identical with the presence of floating bodies in the joint from other causes. In the latter condition the patient, if observant, will usually have discovered the presence of the floating body and have felt it with his fingers in different positions. Such floating bodies are fairly common in arthritis deformans, but the other lesions of this disease are so marked that confusion is not likely to arise. (See, also, Floating Bodies in the Knee-joint.) The X-rays are rarely of any value in the

[1] During his strenuous Arctic trip his knee gave him no trouble.

differential diagnosis. Cartilage, as has been elsewhere stated, casts no visible shadow in an X-ray picture, and floating bodies containing bone or calcareous material sufficient to cast a shadow, are the exception rather than the rule.

I have never seen a case of what appeared to be a fractured or dislocated semilunar cartilage which recovered permanently as the result of conservative treatment. It is at present, so far as I am aware, the consensus of opinion that removal of the injured cartilage is better than the attempt to suture it in place, although I have seen good results follow such suturing in the hands of others, notably several cases operated upon by Dr. Charles McBurney. The removal of the cartilage appears to have no disturbing effect of any moment upon the functions of the joint, except that in some cases the patient finds it desirable, if the internal semilunar has been removed, to avoid, as far as possible, movements which put the internal lateral ligament of the knee upon the stretch.

The diagnosis of *avulsion or of laceration of the crucial ligaments* is not likely to be made before the time of operation. In these cases the ligament is more apt to be torn away from the femur, or to be ruptured, than to tear away with it a portion of bone, either femur or tibia. If the last accident should occur a possible diagnosis might be made by discovering the shadow of a minute portion of bone in an X-ray picture, though its source might be problematical.

OPEN WOUNDS OF THE KNEE AND ITS VICINITY

Open wounds of the skin and subcutaneous tissues of the knee possess no special interest, so long as they do not enter the knee-joint, nor do incised wounds of the deeper structures of the limb present any notable difficulties of diagnosis. The ham-string muscles, the nerves and vessels of the popliteal space, and the external popliteal nerve may be injured in incised wounds, as may be the muscles and tendons upon the front of the joint. No special diagnostic rules, however, other than such as have been given elsewhere, are required for the recognition of these injuries. The surgeon will carefully examine the wound, enlarging it if necessary, in order to determine what structures are injured and how they may best be repaired. The recognition of the extent of the lesion is usually simple during the necessary manipulations.

Wounds of the knee-joint itself, *if infected*, are among the gravest of injuries. The joint is so large and so complicated mechanically, so hard properly to drain, and the power of synovial membranes in getting rid of pyogenic infections is so feeble, that a seriously infected wound of the knee-joint is an injury which gives the surgeon the gravest concern.

The knee-joint may be opened by any sort of direct violence, either as the result of cuts or stabs with knives, daggers, pieces of broken glass, scythes, and the like, or in a considerable proportion of cases the wounds are punctured, as from a blow with, or fall against, the sharp steel hooks which draymen use in moving boxes, or from a blow over the knee-joint from the slipping of a

brad awl such as shoemakers use. Gunshot wounds of the knee will receive separate consideration. In the diagnosis of wounds of the knee-joint it is important to bear in mind that the skin and subcutaneous tissues move freely over the joint structures beneath, and that when the limb is moved from the position in which the wound was received, *the orifice in the skin and the orifice in the joint capsule may not correspond in position.* This is in one way favorable, so long as the joint is not infected at the moment of its infliction, since the wound in the joint itself becomes thereby practically a subcutaneous wound and while suppuration may occur in the wound in the skin, it does not necessarily involve the joint. On the other hand, if the wound is infected at the time of the injury, the surgeon may be misled as to the true condition, and fail to recognize and properly to disinfect, or otherwise care for, the wound in the joint capsule. His attention may not be drawn to the opening of the joint until symptoms of joint irritation appear. Another fact is to be borne in mind in regard to infected wounds of the knee, namely, that the progress of the joint infection is often insidious. The patients may suffer comparatively little pain, the character of the synovial discharge may for a time be only slightly purulent, and there may be for many days but trifling constitutional symptoms. For an illustrative case of this kind the reader is referred to Vol. I. page 98.

The recognition of the fact that a wound opens into the knee-joint may be very easy, or, on the other hand, quite difficult. If the wound is large, the opening in the joint capsule may be visible upon inspection and the escape of synovia may be noticed at once. If, on the other hand, the wound is small, no synovial fluid may escape, and, as stated, the wound in the skin and the wound in the joint may not correspond in position, unless the knee is placed as it was when the injury was received. If there be reason to suspect that an accidental wound may have entered the knee-joint, it will be the duty of the surgeon to approach such an injury with all the aseptic precautions which accompany so serious an operation as is involved in exploring a large joint. It will be his duty to enlarge the external wound and to search carefully for an injury to the joint capsule. If such be found, synovia can usually be made to escape by pressure, in case the joint is opened. The wound in the joint may then be dealt with as circumstances seem to require. The wounded tissues may be disinfected and the joint either sutured or drained, as may seem best in the individual case. If the infection is very slight, suitable drainage, immobilization, the application of wet aseptic dressings and cold, will, in some instances, prevent a serious or destructive panarthritis. If such occur, it may be recognized by the pain, greatly increased by motion, by heat, edema, and sometimes redness of the overlying skin; by the change in the discharge from clear synovia to cloudy fluid, and finally to sticky pus, and by the constitutional symptoms of more or less severe sepsis. In some of the cases, in spite of the most careful surgical treatment, including the transverse incision of the soft parts, thus opening the joint widely with flexion of the knee, the effort to stay the infection will fail, and the patient will, under the most favorable conditions,

survive with an ankylosis, or after amputation of the thigh, though in many cases death will result. (See Diseases of Wounds, Vol. I.)

In 1905 the late Dr. Carleton P. Flint collected the histories of 310 cases of pyogenic infection of the knee-joint which occurred in a number of different hospitals in the City of New York during the preceding ten years. Among these there were 52 penetrating wounds of the joint; 19 were lacerated wounds, 8 were punctured wounds, 3 were gunshot wounds. Of these, 30 or 60 per cent became seriously infected. Among the lacerated wounds about half became infected, and among the fractures of the patella 78 per cent became infected. The results in the 30 cases were, that 4 died with or without amputation, 2 legs were amputated, and 2 knees resected. Among those who survived, there were 20 who left the hospital with varying degrees of disability. Four had complete ankylosis of the knee.

GUNSHOT WOUNDS OF THE KNEE

Gunshot wounds of the knee-joint may or may not be accompanied by injuries of the bones. The latter group constitute the exceptions, the former the rule. The diagnosis of the mere presence of a gunshot wound entering the knee-joint usually offers no difficulties from the position of the wound. The injuries produced may be of the most varied character. A number of cases have been observed in recent wars of gunshot wounds of the knee-joint made by the small caliber rifle bullet which passed through the lower end of the femur, producing merely a simple perforation, with very little comminution of bone, or destruction of tissue. In these cases, if they remain aseptic, the results are exceedingly favorable. See quotation from Makins, under Fractures of the Femur. On the other hand, if the wound becomes infected, if the bullet contuses or tears the popliteal artery, if there is extensive splintering of bone, the results may be and usually are disastrous. The following statistics of gunshot wounds of the joints, showing the improvement in results following the aseptic occlusive treatment of these injuries as compared with the treatment before aseptic surgery was known, are of interest. They are quoted from an article by Major William C. Borden, Surgeon U. S. A., in "American Practice of Surgery," Bryant and Buck, Vol. II, pages 676, 677.

PERCENTAGE MORTALITY FROM WOUNDS OF THE JOINTS IN FOUR WARS

Joint.	American Civil War.	Franco-Prussian.	Japan-China (Haga).	Spanish-American (Regulars).
Hip	84.7	71.8	100.0	0.0
Knee	53.7	48.9	25.0	5.5
Ankle	26.9	24.0	0.0	0.0
Shoulder	31.1	35.5	0.0	0.0
Elbow	9.4	21.2	0.0	0.0
Wrist	12.9	12.6	0.0	0.0

CASES AND DEATHS IN EACH CLASS OF JOINT WOUNDS IN TWO RECENT WARS

Joint.	Japan-China War (Haga).		Spanish-American War (Regulars).	
	Number.	Deaths.	Number.	Deaths.
Hip	1	1	0	0
Knee	16	4	18	1
Ankle	4	0	11	0
Shoulder	4	0	3	0
Elbow	16	0	5	0
Wrist	6	0	6	0
Total	47	5	43	1
Mortality, per cent	..	10.6	..	2.3

These statistics strongly emphasize the caution, that no treatment at all is better than the handling of wounds with dirty fingers or introducing into them dirty instruments, thereby insuring infection. It is probable that von Bergmann first demonstrated the value of the conservative antiseptic treatment of gunshot wounds of joints during the Franco-Prussian War. He treated fifteen cases of gunshot wounds of the knee by occlusive antiseptic dressings and immobilization. They were all serious injuries, and the opening of the joint was complicated by more or less extensive comminution of bone. Fourteen of these cases recovered with movable joints. In the fifteenth amputation was done and death followed. In the same war cases of gunshot wound of the knee, treated by the older methods, died in all but five per cent of the cases.

Gunshot wounds of the knee made by large soft leaden bullets, and by soft nosed small caliber rifle bullets, and by large shell fragments, are apt to be such destructive injuries that amputation is necessary in a large proportion of cases. The localization of bullets in the knee or femur is readily determined by means of stereoscopic X-ray pictures.

A very serious group of open wounds of the knee-joint are constituted by compound dislocations of the knee. In these the popliteal artery and vein are often ruptured, or the artery may be so contused that it subsequently undergoes thrombosis or sloughs; and from the method of production of the injury such wounds are frequently infected. In the statistics, in the Index-Catalogue of the Surgeon-General's Library, at Washington, quoted by Stimson,[1] "of 114 traumatic cases the dislocation was forward in 52, backward in 34, outward in 21, inward in 4, lateral in 1, and by rotation in 3. In 21 of them the dislocation was compound, 11 forward, 4 backward, 6 outward."

If the popliteal artery is torn, or becomes occupied by a thrombus, gangrene of the limb is highly probable. This accident necessitates amputation. In cases of doubt as to whether or not the function of the artery is or will be abolished,

[1] L. A. Stimson, *loc. cit.*, p. 777, 1907.

the condition of the circulation of the limb following the production of the dislocation, and the loss of pulsation in the arteries at the ankle, will be the surgeon's guides as to whether or not amputation must be performed.

INJURIES OF THE POPLITEAL VESSELS

As suggested in the preceding paragraph, injury of the popliteal vessels is a rather common accident as a complication of dislocation of the knee, especially of the forward variety. Injuries of the popliteal vessels are seen not very rarely in the hospitals of the City of New York as complicating injuries in cases of compound comminuted fractures of the lower portion of the femur, the result of railway accidents and the passage of the wheels of heavy vehicles across the thigh. The recognition of the injury can be made sometimes by inspection of the highly complicated wound or from loss of pulsation in the vessels below, etc. Death from shock, or a combination of shock and hemorrhage, is not rare. Amputation of the limb frequently becomes necessary. Here, as elsewhere, however, a cautious and rational conservatism, careful disinfection of the wound, etc., may save life and limb. If the popliteal artery is ruptured by sudden violence, it may, as has already been remarked of other large vessels, be so rolled up in a cord that it does not bleed, and its torn or contused stump may be seen in the wound, if such exist. If the artery is torn subcutaneously, and its lumen is not closed, a large arterial hematoma will form in the popliteal space and pressure upon the accompanying vein will usually cause thrombosis in this trunk also. Gangrene of the limb is a probable sequence. In the cases in which the artery is merely contused, it may subsequently become filled with a thrombus, a condition to be recognized by rules already given. In other cases the contusion may be followed immediately, or after days or weeks, by the formation of an aneurism. (See Popliteal Aneurism.)

FRACTURES OF THE PATELLA

The patella may be fractured by muscular action or by direct violence, the former group being the more common. The accident is much more common in men than in women and occurs most frequently during the active decades of life. It is rare among children.

In the statistics of various observers the injury constitutes from one to two per cent of all fractures. The fractures may be simple or compound. The latter occur, as a rule, from direct violence, the former from muscular action, the result of a powerful sudden contraction of the quadriceps extensor muscle of the thigh, which may directly pull the bone apart, or, it is believed, in some instances may break it across the condyles of the femur. The accident happens from the sudden violent contraction of the quadriceps made in the effort to prevent a fall, or when the leg is forcibly flexed against the opposition of the extensor muscles of the thigh. In the cases produced by muscular action the

line of fracture in most instances passes transversely, or nearly so, across the middle of the bone. The line of fracture may be directly backward through the bone, or somewhat oblique, as from above and in front downward and backward. A few cases of vertical fracture have been reported, and in the fractures by direct violence the bone is usually comminuted. In the fractures by muscular action there is usually separation of the fragments, more or less marked, which increases after the muscles have regained their tone and the joint has become distended with blood. The separation may be in some instances very slight, where the fibro-periosteal covering of the bone is not completely torn, or in other cases the finger sinks readily between the fragments, or the separation may amount to an inch or more. In untreated cases or in cases of failure of union, the separation grows greater with time, owing to the contracture of the ligamentum patellæ and of the quadriceps muscle and may amount to several inches. In addition to the break in the bone the lateral expansion of the tendon of the quadriceps on either side of the patella is more or less extensively torn, and the fibro-periosteal and tendinous covering of the patella is also ruptured. The rupture of the latter usually does not occur at the same level as that of the fracture, but at some distance below, and the fibrous tissues are usually pulled out into a fringe, which very commonly falls over the lower surface of the upper fragment, thus in some cases, as was first pointed out by Macewen and König, interfering with close union between the fragments. The fragments may remain in their normal relations to the femur and tibia, or may be rotated upon a horizontal transverse axis, so that the upper surface of the lower fragment looks forward, or the upper fragment may be rotated in a similar manner. As may be readily understood, the interposition of the torn fibrous structures, and in other cases the rotation of the fragments, render the conditions rather unfavorable for close union by conservative methods of treatment. Immediately after the fracture there occurs a rapid effusion of blood and synovial fluid into the knee-joint, causing a marked swelling of the knee.

In the fractures by direct violence the bone is broken by blows upon the knee as from the kick of a horse, a gunshot wound, or, as in the case related upon page 98, Vol. I, from the blow of a piece of flying iron, the result of a gunpowder explosion. It is, of course, possible that the patella may be fractured by direct violence from falls upon the knee, but in the opinion of most surgeons, including Stimson, this method of production is rare. The fractures by direct violence are, as stated, usually comminuted, but they are not, as a rule, attended by separation of the fragments, the fascia, tendons and ligamentous structures not being torn.

Symptoms.—The symptoms of fracture of the patella are characteristic. At the moment of a sudden muscular effort the patient hears a crack which may be audible to bystanders, experiences a severe pain in the knee, falls and finds himself unable to extend the limb. It may be said, however, that in fractures by direct violence the patient may still be able to walk, although the use

of the limb is accompanied by extreme pain. In the ordinary transverse fractures by muscular action Stimson [1] states:

> In a few cases he has walked, and, indeed, in most it is possible to walk backward, keeping the knee extended by the pressure of the heel on the ground, or even to walk forward if the uninjured limb is advanced and the other swung up to it, but not beyond it.

The patient may fall to the ground and find himself unable to rise. In the ordinary cases, as he lies upon his back, he is not able to lift the heel from the ground. Soon after the accident the joint becomes filled with blood and swollen. Ecchymosis develops after hours, or a day, and is usually extensive. The diagnosis of the fracture is absolutely simple in ordinary cases. There is the history of the accident, the disability as described; the knee-joint is swollen and distended with blood; upon palpation the finger sinks readily between the bony fragments. Pressure upon either fragment is painful, and if the fragments are crowded toward one another, crepitus may sometimes be elicited. This also causes pain. The fragments are independently movable laterally.

FIG. 208.—OLD FRACTURE OF THE PATELLA; MARKED SEPARATION OF THE FRAGMENTS WITH VERY FEEBLE UNION. (Drawing by Dr. B. S. Barringer.)

In the fractures by direct violence the diagnosis is to be made from the history of the injury, sometimes from the presence of a wound extending directly between the fragments into the joint, from the presence of localized pain and tenderness, by the swelling of the joint, and usually by mobility and crepitation, as the fragments are moved one upon the other. In these cases the bone is often broken into several pieces, and this condition also is usually easily recognized. Separation is usually slight.

Repair.—At the present time, unless contraindications exist, a large proportion of fractures of the patella, when it is possible to perform an aseptic operation, are treated by placing the limb upon a posterior splint, by pressure with

[1] L. A. Stimson, *loc. cit.*, p. 366, 1907.

a tight bandage, or an elastic bandage upon the knee, to limit the effusion in the joint and the swelling, by the application of cold in the form of an ice bag, and, at the end of seven or eight days, by an open operation. Apposition of the fragments is obtained by suture through the surrounding fascial and aponeurotic structures. The joint is carefully washed free from all blood with hot sterile salt solution, and an effort is made to use the fewest possible number of instruments and to keep everything else out of the joint. Some surgeons prefer a vertical incision over the middle of the patella, others, myself included, a transverse or somewhat crescentic cut with its convexity downward and not directly over the line of the fracture. Bony union may thus be obtained in a large proportion of cases. It should be borne in mind that no one who is not able to surround his patient with every possible aseptic precaution, such as may be obtained in a modern hospital, or who is not himself accustomed to doing aseptic operations, has any business to operate upon a fractured patella. The result of failures to keep the wound aseptic are too disastrous to justify any unnecessary chances being taken. In those cases in which the fragments may be brought into bony contact, as evidenced by crepitation, and kept there, the nonoperative treatment of fracture of the patella is attended by very good and nearly perfect functional results. Bony union is, however, the exception rather than the rule. Even in those cases in which union is not very close the functional result is, as a rule, satisfactory, although there will usually be some loss of extension. Still, these patients become accustomed to the slight disability and may finally become unconscious of it. In the nonoperated cases there are a number of forms of treatment, the details of which I shall not here describe. During the after treatment the patient should be careful to avoid falls or forced flexion of the joint for a period of several months. The danger of such flexion occurring is best avoided by wearing a light and removable plaster splint, so that massage and gentle motion, with douching, etc., may still be employed.

The open method of operation as practiced by Dr. Stimson in nearly two hundred and fifty cases (1907) has been in his hands absolutely successful, no case of failure having occurred.[1] He uses a central vertical incision, frees the fragments from blood and torn fibrous fringe, and drawing the fragments together with hooks, "passes two or three catgut sutures in the periosteum along the edge of the fracture, or a single silk or stout catgut suture passed through the tendon and ligamentum patellæ, so that its two strands lie in front of the bone. Sometimes additional sutures are placed in the rents in the lateral extension close to the bone. The skin is then closed by the continuous silk suture without drainage."

I have used this method myself, or one very similar to it, in the New York Hospital for some years in a fairly large number of cases with uniformly good results. I prefer, however, not to use nonabsorbable buried sutures.

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[1] Stimson, *loc. cit.*, p. 376.

RUPTURE OF THE QUADRICEPS EXTENSOR TENDON AND RUPTURE OF THE LIGAMENTUM PATELLÆ

The quadriceps extensor, or the ligamentum patellæ, may be ruptured by muscular action of a kind identical with that causing fracture of the patella. Why in the one case the patella should fracture and in the other the tendons rupture, is not known, except in a general way it may be assumed that muscles the seat of any form of degeneration are predisposed to rupture. The quadriceps tendon usually ruptures at its attachment to the patella, and a minute fragment of patella may be torn away at the moment of rupture. The symptoms of the rupture are that as the result of some violence which puts the quadriceps upon the stretch, the patient feels a severe pain in the region of the knee, hears a tearing sound, and his limb gives way under him. Active extension of the thigh is either greatly restricted or impossible, according to the depth and extent of the rupture. If the rupture takes place close to the patella, there may or may not be a considerable effusion of blood into the joint. In the case figured in the text the amount of bleeding was trifling. In other cases which have been described, the rent and the knee-joint are soon filled with an extensive effusion of blood. The diagnosis is, as a rule, absolutely simple. There is a visible and palpable hollow at the upper border of the patella with a separation which in the case shown in Fig. 193 admitted the side of the hand readily. If a large amount of bleeding occurs, the hollow above the patella may cease to be noticeable, but the rent is easily recognized upon palpation. If the rent is extensive and the patient is in good physical condition and the surgeon is able to surround his patient with every possible aseptic precaution and is accustomed himself to aseptic operations, he is justified in repairing the injury by suture. Under other conditions, excellent results, sometimes with perfect restoration of function, may be obtained by conservative methods of treatment.

Rupture of the ligamentum patellæ occurs from similar forms of violence to those above mentioned, and the patient at the moment of rupture again experiences a sharp pain and finds himself unable to extend his leg. The tendon may rupture at its attachment to the tibia, and a small scale of bone may or may not be torn off.

The signs and symptoms are perfectly characteristic. Inspection of the two limbs will show that the patella upon the injured side has risen a variable distance above its fellow, which may amount to from half an inch to two or more inches. The patella is, moreover, freely movable laterally upon the injured side and may be tilted in various directions. In some of the cases, in which the tendon is ruptured close to the tibia, the joint is not opened and no hemarthros occurs. If, on the other hand, the tendon is ruptured, as I saw in one case of my own, close to the patella, a minute fragment of patella being also torn away, there will usually be a greater or less distention of the knee-joint with blood. In the case mentioned I got a good result by catgut suture of the tendinous and aponeurotic structures.

In regard to operating upon old cases of fracture of the patella with much separation and of old cases of rupture of the ligamentum patellæ with notable retraction of the patella, the surgeon must bear in mind, before he undertakes such a procedure, that, if months or years have passed since the original injury the muscles and tendons will have undergone a permanent contraction. In order to bring the fragments of the patella together or the ligamentum patellæ down to the tibia, respectively, it will usually be necessary to make extensive incisions in the muscles of the thigh, and although I have seen some good results follow these operations, in other cases the condition of the patients has not been markedly improved. With a suitable apparatus these individuals are able to get about and to walk with comparative comfort, though no operation be done.

DISLOCATIONS OF THE KNEE

Dislocation of the tibio-femoral joint is a very rare injury. In the statistics of various observers it forms about one per cent of all dislocations. The dislocations may be grouped, in reference to the displacement of the tibia, into anterior, posterior, lateral, either to the inner or outer side, and dislocations by rotation. The accident is a very serious one, as already indicated when speaking of Injuries of the Popliteal Vessels. The artery and vein may be torn or the artery may be so injured by pressure that thrombosis follows. A fairly large proportion of the cases have been followed by gangrene of the limb necessitating amputation. The dislocation is frequently compound. The nerve trunks of the popliteal space may also be severely bruised, stretched, or torn. The most frequent form is dislocation forward.

Forward Dislocation of the Knee.—The injury is most often caused by hyperextension of the leg at the knee, although cases are recorded of direct violence forward to the leg, the thigh being fixed, or of a blow upon the thigh from in front, while the leg was held immovable. A considerable proportion of the cases occur as the result of machinery accidents, when individuals are caught in a moving fly wheel, or by belting, and their bodies whirled round and round, striking against the ceiling or other objects. The associated injuries may, therefore, be very grave and are often fatal. A forward dislocation may be complete or incomplete. In the complete form the tibia, after one or both lateral ligaments and usually the crucial ligaments also, are torn, slides forward upon the femur and the upper end of the tibia comes to lie in front of the condyles. In the incomplete form the posterior border of the articular surface of the tibia rests upon the cartilage of the femur.

The diagnosis of complete anterior dislocation of the knee is entirely simple. The condyles of the femur produce a prominence on the posterior surface of the limb, where they can readily be seen and identified by palpation. The skin upon the anterior surface is thrown into transverse folds just above the joint. The leg is shortened. The antero-posterior diameter of the knee is increased. When viewed from the side with the limb extended, it can be seen that the leg

occupies a plane anterior to that of the thigh. The tibia can be identified readily on the anterior aspect of the limb, and the patella lies in the space between the upper end of the tibia and the displaced femur. The knee is usually completely extended. The injuries of the blood-vessels and of the nerves are to be sought for in the manner indicated elsewhere in this book. The diagnosis of a compound dislocation can be made on inspection.

Posterior Dislocations of the Knee.—These are rarer than the former type and are caused by similarly severe grades of violence, from being whirled about by machinery, occasionally from direct violence either to the leg or to the thigh. In the cadaver the dislocation can be produced only by very great violence. The recognition of the complete forms is entirely simple. The condyles of the femur form a marked prominence upon the front of the limb, and are readily identified with the patella lying between them. The antero-posterior diameter of the limb is greatly increased. The upper end of the tibia forms a marked prominence in the popliteal space. The usual position of the limb is that the knee is slightly hyperextended. The amount of shortening varies with the degree of upward displacement. In the complete forms it may, however, be an inch or two; in the incomplete forms it is less. Injuries to the blood-vessels and nerves should be sought for.

Fig. 209.—Dislocation of the Knee-joint Outward and Backward. Incomplete. (Case of Dr. F. W. Murray.)

The Lateral Dislocations.—These are rare, and the incomplete forms are more common than the complete ones. The dislocation in an outward direction is more common than the inward form. In the outward dislocations the inner condyle of the femur forms a marked prominence on the inner aspect of the knee, while the tibia projects correspondingly upon the other side. The leg may be more or less rotated outward and in a position of extreme genu valgum. The lateral displacement may be combined with an anterior or posterior one. The displacement of the patella is somewhat varied. If the dislocation is compound, the skin over the inner condyle is torn. The recognition of the injury is entirely simple and can usually be made on inspection. In these

cases also serious injuries to the blood-vessels have been observed. In the cases which survive, the internal lateral ligament may remain permanently weakened, so that the leg is in a position of marked valgus. The *inward dislocations* are also extremely rare. They occur from lateral strains which result in rupture of the external lateral ligament. The external condyle of the femur is readily recognized on the outer side of the joint and the head of the tibia projects upon the inner side. The position of the leg varies in different cases. It is often abducted or adducted, sometimes rotated.

Dislocations by Rotation.—These are forms scarcely requiring a separate description. They have been readily recognized in the reported cases and have been produced by rotation of the leg carried to the extent that the lateral ligaments gave way.

In a general way the reduction of dislocations of the knee is not difficult. In all cases it should be borne in mind that the popliteal vessels may be injured. Some difficulties of diagnosis have occasionally occurred in the incomplete lateral forms. In cases of doubt the X-rays would demonstrate the position of the bones clearly.

Congenital Dislocation of the Knee.—Congenital dislocation of the knee due to deformity of the bones entering into the joint is rarely observed, associated then with very marked deformities of other bones. A moderate number only of anterior congenital dislocations, unilateral and bilateral, have been observed at birth, presumably as the result of intra-uterine pressure upon the extended knee. The child may be born with one or both knees hyperextended to a right angle with the femur, or the foot may even touch the groin. The condition is readily recognizable on inspection and palpation. A rare deformity of the knee is the so-called congenital genu recurvatum.

FIG. 210.—CHARCOT'S KNEE-JOINT OF THE DESTRUCTIVE TYPE. (Collection of the late Dr. W. J. Vought.)

Congenital Genu Recurvatum.—In these cases the tibia may be greatly hyperextended upon the femur. The extensor muscles are shorter than normal, while the flexors are relaxed or abnormally long. The children are able to hyperextend the knee-joint to a variable degree. The cause of the condition is similar to the more marked forms described in the preceding paragraph

Pathological Dislocation of the Knee.—As the result of a variety of diseases of the structures entering into the knee-joint, the various forms of arthritis, arthritis deformans, tuberculous disease, or the panarthritis of suppuration, the tibia may be more or less completely dislocated backward or backward and laterally with rotation upon the femur. Similar dislocations are observed as the result of the destructive joint lesions of tabes, Charcot's knee. (See Fig. 210.) The tibia may be displaced directly backward, or backward displacement may be combined with external rotation and outward displacement of variable degree. In tuberculosis of the knee-joint, untreated cases gradually develop a more or less marked backward dislocation of the tibia, usually combined with outward rotation. The actual condition of the bones is readily recognized on palpation, and may be very clearly shown in an X-ray picture. It is important to bear in mind in this connection that the flexor muscles and other structures upon the back of the limb are permanently shortened, and that in resecting such knees, care must be taken to cut off enough bone to avoid any tension upon the structures of the popliteal space. I have seen a case in which failure to appreciate this necessity led to thrombosis of the popliteal artery, gangrene of the limb, and amputation, followed by death.

DISLOCATIONS OF THE PATELLA

The patella may be dislocated inward or outward, or may be rotated inward or outward upon a vertical axis, so that it stands upon edge in the groove between the condyles. The dislocation is a very rare one, the frequency with which it occurs being even less than is the case with dislocations of the knee. The bone may be displaced either by direct violence or by muscular action.

Lateral Dislocation of the Patella.—Lateral dislocation of the patella is the most frequent form, and in most of the reported cases the dislocation has been outward. It may be incomplete or complete. In the first case the edge of the patella still remains in contact with the edge of the articular surface of the condyle. In the complete cases it is still further displaced outward. The dislocation may occur as the result of blows and falls upon the inner bor-

FIG. 211.—CONGENITAL ABSENCE OF BOTH PATELLÆ. No notable loss of function. (New York Hospital collection.)

der of the patella, or by such injuries combined with the forcible contraction of the quadriceps muscle. As the patella leaves its place, the capsule of the joint is torn more or less extensively, usually in a vertical direction. The diagnosis of the dislocation is entirely simple. The limb is in a position of genu valgum, slightly flexed and the leg rotated a little outward. The patella is readily identified on palpation on the outer aspect of the lower end of the femur and above and below can be felt the tense extensor tendons. To the inner side upon palpation, the finger sinks into the groove between the condyles. The dislocation is usually readily reduced. In a certain number of cases, if the limb is not kept immobilized for a sufficient length of time, the dislocation may become habitual and this will be especially true where a notable degree of genu valgum already exists. In the inward dislocations, which are much more rare, the patella is displaced toward the inner side and is readily recognized as such. Combined with these lateral displacements, the patella may be rotated to any extent up to 90° upon a vertical axis, even so that its articular surface presents beneath the skin. In rare cases the patella may be rotated upon a vertical axis, so that it rests on edge upon the condyles. The recognition of the condition is absolutely simple. In the complete rotations about a vertical axis, the displacement may require an open operation for reduction.

FIG. 212.—THE SAME CASE WITH THE KNEES IN THE POSITION OF FLEXION.

Dislocations of the Patella Downward or Into the Space Between the Tibia and Femur.—In most of the observed cases the quadriceps tendon has been torn. In one, that of Szumann, the extensor apparatus remained intact and the quadriceps tendon was dislocated on to the outer surface of the knee. The ligamentum patella was twisted but intact. The crucial ligaments and the external lateral ligament were torn. The patella was wedged in between the tibia and femur, and its articular surface was directed upward. The patella lay between the outer condyle of the femur and the tibia. In another similar case reported by Küttner, the articular sur-

face of the patella was directed downward toward the tibia. In all, but eight cases have been reported. They are all quoted by Stimson.[1]

Congenital Dislocation of the Patella.—A very moderate number of cases of congenital dislocation of the patella have been reported. The condition appears to be to some extent an hereditary one. It has been investigated by Bessel-Hagen, who distinguished three forms. 1. An incomplete dislocation, the patella lies upon the external condyle. Upon flexion of the knee it returns to its normal position. 2. The complete intermittent form. The dislocation recurs every time the knee is flexed and the patella returns to its normal position when the limb is extended. 3. The complete permanent dislocation. The patella lies displaced outward during extension of the knee and upon flexion is still further displaced outward. Bessel-Hagen found three cases of congenital dislocation of the patella among a family of brothers and sisters. In two cases observed and reported by Appel one was a man aged forty, the other aged twenty-six. Apparently permanent changes existed in the shape of the external condyle. It was flattened and narrower than normal. He found a similar deformity in thirteen cases described. Congenital dislocation of the patella may produce no special symptoms for a long time. If, however, no precautions are taken to avoid it, a very marked genu valgum or knock-knee condition is produced, which may give the patient much discomfort and cause an ugly deformity as well as an awkward gait.

[1] L. A. Stimson, *loc. cit.*, p. 806.

CHAPTER XXIII

DISEASES OF THE KNEE

ACUTE serous synovitis of the knee-joint has been sufficiently described in the preceding chapter and in Vol. I, under Diseases of Joints.

Intermittent hydrops of the knee is also described in Vol. I, page 170. For the pathology and lesions of the acute exudative inflammations of joints the reader is referred to Vol. I, Chapter IV. A brief consideration of the exudative inflammations of the knee-joint will here be given in so far as there are special peculiarities accompanying these affections of the knee. As has been pointed out in Vol. I, and elsewhere, the synovial membrane of a joint may react in a variety of ways when irritated by mechanical, chemical, or toxic insults. Thus, the knee-joint may become inflamed as we have seen from contusions or wounds, and under such circumstances the exudate may be serous or bloody, or a combination of these ingredients, or after infection, whether due to an open wound or to the localization of a generalized process of bacterial character in the knee, there may follow exudates—serous, serofibrinous, catarrhal, or distinctly purulent. A great variety of infectious diseases, including the various septic diseases of wounds, septicemia, pyemia, etc., as well as special infectious diseases, the exanthemata, pneumonia, polyarticular rheumatism, gonorrhea, erysipelas, may be followed by an inflammation localized in the knee-joint. The character of the exudate and the severity of the inflammation will vary greatly in different cases, irrespective of the character of the general infection. The most severe and destructive types of arthritis are those which follow direct infection of the joint, from open wounds of the joint itself, infected compound fractures involving the joint, gunshot wounds, and similar injuries. For the signs and symptoms of simple traumatic synovitis the reader is referred to Vol. I and to the preceding chapter, and for the special characters of the special forms of synovitis or arthritis the reader is referred to chapters on the Upper Extremity and also to Vol. I. Suffice it here to say that the local signs of the inflammation, the constitutional symptoms, the disturbances of function, or, on the other hand, the destruction of the joint, vary through every possible grade of severity, from a slight serous effusion attended by few symptoms to a panarthritis of an intensely septic character accompanied by pyemic chills, rapid disintegration of the cartilages and of the ends of the bones, purulent infiltration and softening of the ligaments followed by diffuse septic infiltration of the tissues of the thigh and leg. For

examples of these several conditions the reader is referred to Vol. I. The more severe the infection the more severe and pronounced will be the local symptoms and the constitutional disturbances. The character of the exudate may often be inferred from the character and origin of the systemic infection, and may be demonstrated by aspiration of the joint, with microscopic and bacteriological examination of the exudate. The results of acute infections of the knee also vary within wide limits. In the most favorable cases where the infection is of slight severity, a return to normal, with perfect restoration of function, may be obtained. In other cases a more or less marked stiffness and even fibrous ankylosis may remain. This is notably true of the more severe forms of gonorrheal inflammations of the knee. In the distinctly septic cases the most favorable result is ankylosis, and in many instances amputation will be necessary to save life, or the patient will die in spite of such an operation.

TUBERCULOUS ARTHRITIS OF THE KNEE OR TUBERCULOSIS OF THE KNEE-JOINT

The pathology, symptoms, and clinical course, together with some remarks on differential diagnosis of tuberculosis of the knee-joint, have been discussed in Vol. I, Chapter IV, to which the reader is referred. Some additional data are here given, together with a few remarks on the diagnosis of bone and joint tuberculosis by means of the several tuberculin tests and some notes on treatment.

All the varieties of tuberculosis of joints are observed in the knee, and the joint is so superficial that most of them can be here studied to great advantage. The knee-joint is one of the favorite sites for the localization of tuberculosis. The disease is one of youth, and the male sex is affected slightly more often than the female. In regard to the age of these patients, König's statistics are as follows: 704 cases were seen; 292 of these occurred during the first decade of life, 190 in the second, and 93 in the third. As was stated in Vol. I, the disease is in the largest proportion of cases primary in one of the bones entering into the joint, primary synovial tuberculosis being rarer in children than in adults. Here, as in other joints, at the time of operation, if operation be done, or at autopsy, it may be extremely difficult to tell whether the disease originated in the bone or in the soft parts, and perhaps some cases of joint tuberculosis, supposed to be primary in the bone, may be due to a secondary invasion from the synovial membrane. Still, in a fairly large experience in the hospitals of the City of New York, my experience has been that the number of cases of tuberculosis of the knee-joint primary in the bone has very largely exceeded those which appeared to me to be primary in the synovial membrane. In the vast majority of cases the infection is in the nature of a tuberculous embolus, which lodges in one or other of the condyles of the femur, or in the upper end of the tibia. A place of diminished resistance in the bone is believed

to be created in a moderate number of cases by a preceding trauma, usually not of a severe grade. To recapitulate briefly the signs and symptoms of the disease, it may be said, as follows: that the beginning of the joint infection is usually insidious; it may be preceded by slight pain and tenderness, scarcely noticeable, at the point of infection in the bone, before the joint is infected. The first symptoms of joint irritation are, slight lameness and pain, referred to the knee-joint itself and a limitation of motion, almost invariably in the direction of extension—that is to say, these patients keep the knee-joint constantly a little flexed. Any attempt to straighten the knee beyond a definite point is attended by spasm of the muscles of the limb and sharp pain. Crowding together the joint surfaces, or a slight blow upon the heel, causes pain in the knee. This limitation of motion in the direction of extension and increase of flexion is, in untreated cases, progressive throughout the course of the disease; and in well-developed cases is accompanied by a more or less marked outward rotation. In time this may lead, as elsewhere stated, to a partial or complete dislocation of the tibia backward. In no joint of the body is the characteristic spindle-shaped swelling of the limb more distinctly marked than in the knee. It is made more prominent by the atrophy of the muscles of the leg and thigh, which takes place early and may become excessive. The amount of shortening observed in knee-joint tuberculosis is trifling or absent. Indeed, the unopposed growth of the lower end of the femur and upper end of the tibia may produce an actual lengthening of the limb. The formation of cold abscesses is common in tuberculosis of the knee-joint, and if untreated such abscesses may become secondarily infected with pus microbes, with the production of acute and chronic sepsis. The *pain* in tuberculosis of the knee-joint is referred to *the knee itself* in this way, differing from the same disease in the hip. The lameness increases with the amount of flexion, and when the disease is well advanced the children walk with difficulty and pain upon the toes of the flexed limb. Acute sudden outbreaks of inflammation with so-called joint abscesses, described in Vol. I, are quite common in tuberculosis of the knee.

In the worst cases the progress of the disease is very rapid and total destruction of the knee-joint with marked constitutional symptoms may occur in a few weeks or months. The X-rays are at times a very valuable aid in tuberculosis of the knee-joint. It may be possible to recognize upon the X-ray plate the lightened areas produced by bone destruction in the epiphysis of the femur or in the head of the tibia. *I do not consider* from my experience that the X-rays are of *great negative value* in the diagnosis of tuberculosis of the knee-joint. Unless conditions are favorable, a small focus in the bone may be missed in the X-ray picture. As in other tuberculous lesions, there is a certain tendency toward spontaneous healing in some cases of tuberculosis of the knee-joint. Advantage of this is taken in the conservative treatment of these cases. Fixation of the joint in a suitable position by apparatus, and protection against further injury, with the avoidance of pressure between the joint surfaces, fre-

quently results in cure. By cure it must not be understood that perfect restoration of function in the knee can be expected. Such an event is extremely rare; in most instances some deformity and some limitation of motion remain. In bad and neglected cases, notably, if combined with pyogenic infection, the patients may go on to die of chronic septicemia with amyloid degeneration, or of tuberculosis in other situations. The latter accident is, of course, possible in any case. Resection of tuberculous knees which are not doing well under conservative treatment in adults is attended by excellent results in so far as cure of the tuberculous lesion goes. A stiff knee-joint in the extended position is, however, an uncomfortable limb for many reasons. The ordinary acts of life, dressing, lacing the shoes, putting on the stockings, etc., are troublesome when the knee is stiff. Therefore many surgeons prefer conservative treatment whenever it is possible. The choice of the treatment must also depend to some extent upon the station in life occupied by the individual. Among the well-to-do the conservative treatment is justifiable in many instances, while among adults of the laboring class it is not practicable.

Fig. 213.—Deformity Following Resection of the Knee-joint for Tuberculous Arthritis in a Child; Due Partly to Irregular Growth of Bone. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

In children resection of the knee is an operation which should, if possible, be avoided. The younger the child is, the more desirable that the case be treated by conservative means. The reasons for this objection to resection are, that in some cases the epiphyseal cartilage of the femur or tibia may be destroyed, thus seriously interfering with the subsequent growth of the limb. Secondly, even though the epiphyseal line be not invaded, it often happens that subsequent to the resection an uneven growth occurs in the limb, which may, in the first place, lead to shortening or to angular or rotary deformity in one direction or another; sometimes to flexion, sometimes to abduction or adduction. The epiphyseal cartilage of the lower end of the femur follows a line nearly parallel to the lower curve of the condyles, and presents two concavities, which at the age of sixteen are 7 or 8 mm., or one third of an inch above the periphery, and at the age of five from 5 to 6 mm. That of the tibia is more nearly straight across and about 3 or 4 mm. from the edge of the articular surface of the bone

(König[1] and Ollier).[2] In some bad cases, however, in young children, who are not doing well under conservative treatment, we are forced to select one of three operations—namely, amputation, resection, or a partial arthrodectomy with the removal of only so much of the articular surfaces of the bones as appears necessary to eradicate the disease. The capsule of the joint must, of course, be cleanly dissected out. In the event of selecting this third operation, it will often happen in children that amputation becomes necessary in the end.

In adults I have been in the habit, following the practice of Dr. Charles McBurney, to recommend resection of the knee, even though the disease was not attended by the formation of abscesses and sinuses. These patients do not do very well as the result of immobilization of the limb by apparatus. They suffer a good deal of pain and disability and are constantly exposed to relapses and exacerbations of the disease from missteps, blows, or falls upon the affected joint, so that they become very timid and afraid to go about without a cumbersome apparatus, which renders them more or less conspicuous, and is always more or less troublesome. Moreover, tuberculosis of the knee, even though it become inactive, or undergo spontaneous cure, is very rarely attended by so firm an ankylosis that ordinary wrenches and sprains may not cause disability. Following a resection, on the other hand, the deformity is not conspicuous and the patients acquire great confidence in the strength of the bony union following a successful resection.

The Tuberculin Tests for Tuberculosis

As a general rule the diagnosis of surgical tuberculosis may be made with certainty without the aid of other means than have been elsewhere described in this book. The several tuberculin tests are used with advantage in general medicine and in skin diseases, and also to some extent by surgeons in doubtful cases. They cannot as yet be considered absolutely conclusive in all cases, and some of them, notably the conjunctival tuberculin test of Calmette or Wolff-Eisner, are in a few cases attended by disagreeable results. The author has a personal experience with the use of these tests, but has waited, having omitted them from Vol. I intentionally, until the greatest possible amount of time had elapsed, so that he might utilize very recent conclusions. One of the most careful observers in this field, Mary C. Lincoln, M.D., published in the *Journal of the American Medical Association*, Chicago, Ill., November 21, 1908, an article on "Serum Diagnosis of Tuberculosis. The Tuberculo-opsonic Index. The Von Pirquet Skin Test and the Conjunctival Test." I have utilized the information in her article to a great extent. Another article—"Conclusions from 1,087 Conjunctival Tuberculin Tests by a Uniform Method," Edward R. Baldwin, M.D., Saranac Lake, N. Y.—appeared in the same journal,

[1] "Archiv für klinische Chirurgie," neunter Band, p. 190, published in 1867.
[2] "Traité des Resections," tome iii, Paris, 1891.

the issue of February 20, 1909, and from that also I have gathered and utilized in the following section certain of the contained data. Briefly the von Pirquet tuberculin test is thus applied, details having been taken from an article by Dr. Lincoln.

The materials used in the test are a twenty-five-per-cent solution of Koch's old tuberculin. This solution is made as follows: One part five-per-cent carbolic acid in glycerin and two parts sterile 0.85-per-cent salt solution, and a blank solution consisting of one part five-per-cent carbolic acid in glycerin and three parts sterile 0.85-per-cent salt solution. To preserve the two solutions in a sterile manner without evaporation and to have a definite amount for each test, a measured drop is drawn into capillary tubing and sealed. A convenient method of doing this is to draw out glass tubing three eighths of an inch in diameter into long lengths of capillary size, fit a rubber teat on the large end, aspirate a measured drop through the capillary end, seal end, and also about 5 cm. from the end so as to inclose the column of liquid in the capillary tube. A large number of capillary tubes of tuberculin can be made up at one time, since the solution keeps indefinitely.

The scarifier may be metal or glass, but should not be sharp enough to break the skin. The one used by myself has a flat-sided metal tip about one sixteenth of an inch in diameter, the edge of which is used in scarifying. A very satisfactory one can be made by filing down the end of a blood lancet to a round flat-sided tip.

Application of the Test.—A small area of skin on the inner side of the forearm, or other convenient situation, is sponged off with ether. A tube containing twenty-five-per-cent tuberculin and a tube containing blank solution are broken off at either end. Two drops of the tuberculin are blown on the arm about one and one-half inches apart, and one drop of the blank solution between the two drops of tuberculin. The scarifier is rubbed off with ether and the edge of its tip is revolved about four times in the drop of tuberculin, holding the scarifier at right angles to the skin and using enough pressure to slightly dent the skin. The operation is repeated in the second drop of tuberculin, the scarifier is again cleaned with ether. The spot covered with blank solution is then scarified. The only immediate result will be three tiny depressions in the skin in the center of the three drops of liquid. Allow the drops to dry, or cover with vaccination shields until dry.

The Reaction.—Usually at the end of twenty to twenty-four hours the reaction, if any appears, is at its maximum. A typical reaction consists in a hyperemic indurated swelling about 1 cm. in diameter, with a deeper colored pinhead-sized central depression. The blank shows nothing, or rarely a dull red point. Occasionally a more marked tuberculin reaction results, that is vesical formation in the center, a hyperemic swelling of twice the usual size, and finally crust formation. The reaction subsides in from one to four weeks by gradual diminution of the hyperemia and induration if the reaction was of the mild grade, and by desquamation if the reaction was severe. No constitutional effect has ever been noted. The only subjective symptoms are a slight grade of itching and some tenderness when the reaction is severe. A primary attempt was made to classify the reactions on the basis of their intensity and duration, but such detailed data add nothing to the essential value of the test.

The Conjunctival-Tuberculin Test

Material.—Tuberculin tablets for this test are procurable from Parke, Davis & Co. The tablets are used as follows:

One tablet added to 1 c.c. sterile 0.85-per-cent salt solution made a one-per-cent solution. This solution is clear, but is not permanent and becomes cloudy in three or four days, so that fresh solutions should be made whenever the test is to be applied.

The Method of Application.—The condition of the conjunctivæ should be carefully examined for areas of congestion. The solution is warmed and one drop is instilled into one eye, holding the lower lid out from the eyeball, and allowing the drop to spread over the conjunctival sac by gentle manipulation of the lower lid before permitting the eye to be closed.

The Reaction.—It is customary to examine the eyes from hour to hour to watch each stage of the reaction, but in the belief of Dr. Lincoln that is not necessary. The important point is as to whether there is or is not a positive reaction.

The reaction varies from a mild to a severe grade of conjunctivitis, reaches its maximum in from about twenty-four to thirty-six hours, and subsides in from forty-eight hours to one week. As in any catarrhal conjunctivitis, there is a bright, brick-red conjunctival injection in coarse meshes, most pronounced in the fornix and toward the inner canthus and fading toward the cornea. In the meshes of the injected vessels the conjunctiva is ecchymotic. The caruncle is hyperemic and edematous. There is edema of the lids, especially the lower, so that in the more severe reactions there is a narrowing of the palpebral aperture. There is usually an increased lacrymation, and in the more severe reactions a mucus or muco-purulent secretion, which, accumulating during the night, may close the lids. There are no subjective symptoms in the mild grades, but in the more marked reactions a sensation of a foreign body in the eye and a burning and smarting, with photophobia, is present.

As is to be expected, the strength of the tuberculin solution has much to do with the intensity of the reaction. In my hands a 0.5-per-cent solution for children and a one-per-cent solution for adults has given the typical conjunctival injection without the more severe symptoms of conjunctivitis, except in a very few cases. In no case have I used a stronger solution than one per cent, and in no case have I made more than one instillation.

The Tuberculo-Opsonic Index

Dr. Lincoln states that the opsonic indices reported in her paper were determined by Miss Stella Dunlap, in the trustworthiness of whose technic Dr. Lincoln has great confidence. The cases tested were divisible into three groups. First, cases clinically nontuberculous. Second, cases of bone and joint tuberculosis, and third, cases of advanced pulmonary tuberculosis. The nontuberculous and the bone and joint tuberculous cases consisted chiefly of childre

ranging from two to fourteen years; a small per cent were adults. A number of cases of chronic tuberculosis of the lungs were also tested. Dr. Lincoln reports the result of the different tests at length in very complete tables, and her comments upon the results of the tests are as follows:

1. The three tests do not agree in every case. Eighty per cent of the cases that yielded positive results to both the von Pirquet and the conjunctival tests were verified by the opsonic index. The von Pirquet and conjunctival tests agreed in 92 per cent of the nontuberculous, in 69 per cent of the cases of bone and joint tuberculosis, and in 64 per cent of the cases of pulmonary tuberculosis.

2. In spite of the disparity in the results of the tests on the same cases, the sum total of positive results is very nearly the same for each of the tests.

3. As is to be expected theoretically, the more advanced the disease—that is, the lower the reacting power of the individual, the smaller the percentage of positive results to the tuberculin tests. *As seen in Table II, there were only 45 per cent positive von Pirquet reactions and 33 per cent positive conjunctival reactions among the advanced cases of pulmonary tuberculosis, while there were 77 and 87 per cent, respectively, positive among the cases of surgical tuberculosis.* (Author's italics.)

4. A study of the tuberculo-opsonic indices given in Table I shows that there is a larger percentage of fluctuating indices in the cases of advanced disease and a larger percentage of low indices in the cases of less advanced diseases. It is interesting to note (Table II) that the percentage of variations of the opsonic index from the normal is about the same as the percentage of positive reactions to the tuberculin tests in the less advanced cases, and is greater in the more advanced cases.

5. Table I shows considerable variations from the normal tuberculo-opsonic index of the indices of the nontuberculous cases. This may, perhaps, be explained by the generally lowered resistance of many of these cases, even though they were clinically nontuberculous. We have previously found that the normal tuberculo-opsonic index ranged from 0.8 to 1.2, as determined from an examination of over one hundred healthy individuals.

6. It is of interest to note that the opsonin content of the blood remained essentially the same after the conjunctival tuberculin test as measured by the opsonic indices taken on the two days following the test.

TABLE II

(Summary of Table I)

Class of Cases.	Von Pirquet-Tuberculin Skin Test.		Conjunctival Tuberculin Test.		Opsonic Index.			
	Number of Cases.	Per Cent Positive.	Number of Cases.	Per Cent Positive.	Number of Cases.	Average of O.I. above or below Normal Range, e.g. 0.8–1.2 Per Ct.	One or more O.I. above or below Normal Range. Per Cent.	Two or More O.I. above or below Normal Range. Per Cent.
Nontuberculous	31	1.3	30	0.3	31	1	35	1.3
Bone and joint tuberculosis	53	77	55	87	56	36	75	43
Pulmonary tuberculosis, Stage III	79	45	80	33	81	24	65	23

Dr. Lincoln states that in reviewing the work of others and from her own experience, she can see no class to which the one or other test is especially applicable.

Danger of Tests

In regard to the dangers of the several tests Dr. Lincoln says:

As to the danger of the tuberculin tests, there is no published reports of any harmful results from the von Pirquet skin test, but the same cannot be said of the conjunctival test. Opinions differ. Isolated cases of violent reaction and persistent harmful results have occurred from the conjunctival test, so, on the other hand, have negative results followed the test in cases of many different diseases of the eye. It is generally conceded, however, that any inflammatory disease of the eye is a contraindication to the test. No harmful results whatever have followed thus far in my series of cases, although there were four severe reactions, but in no case was there any inflammation of the eye present at the time of the test.

The fact that harmful results do occasionally follow the test, the fact that any local tuberculous process in the eye is aggravated, at least temporarily, and the fact that a local susceptibility to tuberculin appears to be produced by its instillation into the eye as evidenced by the lighting up again of the reaction following the subcutaneous injection of tuberculin, seems to me to show definitely that caution should be exercised in applying this test until we have learned more about what the reaction really is.

Prognostic Value of the Tests

It is the common experience of those who apply these tests to find that the highest grade of infection gives the lowest percentage of positive reaction to the von Pirquet and the conjunctival test, but gives the largest percentage of fluctuating opsonic indices.

As to the significance of the intensity of the reaction in prognosis Cohn states that the highest grade of infection shows the weakest reaction. Letulle, on the other hand, concludes the degree of infection and the location of the disease appear to have no effect on the intensity of the conjunctival reaction. Wolff-Eisner and Teichmann believe that the cutaneous and conjunctival reactions show a typical disappearance by "law," depending on the stage of the disease. They distinguish three types: (1) The normal reaction with favorable prognosis, (2) the weak reaction characterized by rapid rise, small intensity and rapid subsidence with unfavorable prognosis, and (3) the late and more permanent reaction seen in patients who show no marks of active tuberculosis.

In my experience the intensity of reaction counts for little, as I have had marked reactions in all stages of the disease, and have had very slight reactions equally commonly. On the whole, however, the cases of surgical tuberculosis and early pulmonary tuberculosis manifested a more marked reaction than those of advanced pulmonary tuberculosis.

Conclusions

1. The percentage of positive reactions to the von Pirquet tuberculin test, the conjunctival tuberculin test, and the tuberculo-opsonic index are substantially the

same, ranging from eighty to ninety per cent in favorable cases, and from thirty to forty per cent in unfavorable cases.

2. The more advanced the disease the smaller the percentage of positive reactions. The intensity of the reaction does not consistently follow any rule, but tends to be greater in cases of less advanced disease.

3. The von Pirquet tuberculin test seems harmless. The conjunctival tuberculin test should be used with caution.

4. Until we can use the tuberculin tests with more intelligence than our present experience makes possible, I believe we should make more comparative tests in all stages of the disease.

The conclusions drawn by Dr. Baldwin [1] are as follows:

1. The conjunctival tuberculin test performed with weak solutions by a single instillation has some value in confirming the presence of tuberculosis in the early stages.

2. It has little value in confirmation when the symptoms of tuberculosis are only suspicious.

3. Its value in distinguishing "active latent" from healed tuberculosis in apparently healthy persons has not yet been determined.

4. Repetition of the test in the same eye has no advantage over the cutaneous and subcutaneous tests in the percentage of reactions produced and may be misleading and dangerous.

5. Repetition in the other eye by the author's method offers so little advantage that it cannot be recommended.

6. The conjunctival reaction is unreliable for prognosis.

7. Used with the proper precautions, danger to the eye is slight and need not preclude the test when other methods are inapplicable, as when fever is present. It should be restricted to adults, since the cutaneous test has been found equally valuable for children and is harmless.

8. The cutaneous test by the simultaneous use of dilute and strong tuberculin offers a method of detecting at once or excluding tuberculous infection with no danger or inconvenience. Experience is needed to show the value of this method.

9. The subcutaneous test should be restricted to those cases in which a focal reaction at the site of the disease is desired and when the other tests result negatively.

DISEASES OF THE KNEE IN HEMOPHILIA

As mentioned in Vol. I, the knee-joint is the favorite site for the occurrence of intra-articular bleeding in cases of hemophilia. As there stated, the effusion into the joint may occur spontaneously, or as the result of slight trauma. The effusion frequently occurs with great suddenness; it is not, as a rule, attended by pain, the picture being simply that of a sudden distention of the joint with fluid, as elsewhere described. In cases in which other members of the family

[1] "Conclusions from 1,087 Conjunctival Tuberculin Tests by a Uniform Method," Edw. R. Baldwin, M.D., Saranac Lake, N. Y.

are bleeders, or when the individual himself is known to be such, the diagnosis may be suspected. It is sometimes confirmed by the appearance of ecchymosis upon the skin after some days. In some cases the blood is promptly absorbed; in others repeated hemorrhages occur with limitation of motion in the joint and adhesions between the folds of synovial membrane, or, in still others, a chronic arthritis attended by a villous proliferation of the synovial membrane. *In these cases great difficulty may exist in differentiating the condition from tuberculosis.* The signs and symptoms so closely resemble one another that even highly experienced surgeons have operated upon these cases, believing them to be tuberculous, and have proceeded to excise the synovial membrane. In some of these the bleeding has been uncontrollable and fatal. If the case is operated upon soon after hemorrhage occurs, fluid blood or clotted blood may be found. If not until a later period, cloudy serum and masses of fibrin will be found in the joint cavity. The appearances of the synovial membrane are, that it is swollen, often thickened, red or grayish red in color, the surfaces rough or velvety. Firm adhesions may be found here and there throughout the joint. In some instances the cartilages are more or less fibrillated or even eroded. The history may in some cases lead to a correct diagnosis, but in others, as already mentioned, very good surgeons may be deceived.

SYPHILIS OF THE KNEE-JOINT

In both the acquired and hereditary forms of syphilis the knee-joint is very frequently involved. As already described in Vol. I, during the early stages of the disease the affection runs the course of an acute serous synovitis, usually without very marked symptoms and with a rapid return to the normal. In the tertiary stage, a chronic gummatous osteo-arthritis is the rule, with the lesions which have been described elsewhere in this book. The outward appearances of a syphilitic joint resemble more or less closely those of tuberculosis, but differ from it in that there is not the same tendency toward breaking down and the formation of abscesses. Such may occur, but in syphilis of joints they are rather rare. Marked deformity, flexion, and often abduction may develop in the knee-joint and frequently limitation of motion and great disturbances of function. The syphilitic joint, however, differs from that of tuberculosis in that in the former there is, as a rule, *very little pain attending* the use of the joint, although the joint structures may be extensively disintegrated. If pain occurs, it is commonly worse at night. The diagnosis at the present time would doubtless be aided by the blood tests for syphilis and for tuberculosis, respectively, and would be helped by the administration of iodid of potassium. Moreover, syphilities are usually older than tuberculous subjects, and other evidences of the disease are often present. In syphilis, moreover, gummatous nodules may sometimes be detected in the soft parts surrounding the joint, and there may be distinct nodular enlargements of the ends of the bones more marked than is observed in tuberculosis.

The syphilitic affections of the joints of children have been sufficiently described in Vol. I.

CHRONIC DEFORMING INFLAMMATIONS OF THE KNEE-JOINT

(*Chronic Rheumatism of the Knee-joint, Rheumatoid Arthritis, Osteo-arthritis, Proliferating Arthritis, Arthritis Deformans*)

As was stated in a previous chapter of this book (see Diseases of the Hip-joint and Diseases of the Joints of the Upper Extremity), certain chronic disturbances of joints occur, presenting a number of lesions, variously grouped, and characterized by a very chronic course, by permanent changes in the joint structures, including the bones, the cartilages, the ligaments, the synovial membrane, and the muscles of the limb, these changes being partly of a productive and partly of a destructive character. Under the headings previously noted, the pathology of these conditions and their varieties have been discussed. Here it may be said that of all the joints in the body, the knee-joint is the one most often affected *alone*. In the majority of instances the disease occurs in the poly-articular form. It may arise spontaneously, or follow injuries to the joint, usually of such a character that either the proper mechanical relations of the joint surfaces are destroyed, or that there is a permanent relaxation of the ligaments, or that, from angular or curved deformity of the bones, the weight of the body is brought to bear improperly upon the joint surfaces. In the spontaneous cases the diagnosis may be rather difficult. In the other groups it is usually quite simple. In the knee-joint, as in other joints, a number of types of the disease may occur, but in the knee in adults *two types* are more common than the others—namely, the type characterized by the production of *new bone* —the formation of *osteophytes*, situated chiefly at the margins of the articular surfaces, and by *destruction of the cartilages* and of portions of the bones entering into the joint by continued mechanical pressure. *The second* type is that in which there is a tendency to the *production of adhesions* in the joint, preceded in many instances by a productive synovitis and by the formation of a synovial pannus. In the *former* group the diagnosis can usually be made after the disease is well advanced with great certainty by means of the X-rays. In the *latter*, the bony changes may be delayed for a long time, and ankylosis may occur in these cases before any notable deformity of the ends of the bones is present. In this group the X-rays are less valuable in diagnosis and the disease is not infrequently mistaken for tuberculous infection of the joint. The differentiation may usually be made, however, by *aspiration* of the joint and *inoculation of guinea pigs*. If the disease is tuberculous, the inoculation test will usually be successful. In a large proportion of cases the existence of similar lesions in other parts, and notably in the *joints of the fingers* will aid greatly in the diagnosis.

Symptoms.—The symptoms of the disease during the early stages vary somewhat in different cases. In a few, the early symptoms begin as a more or less

acute inflammation of the joint. The onset of the disease may resemble that of an attack of acute or subacute articular rheumatism, and the diagnosis will not be made until after the acute symptoms have subsided, when the joint lesion becomes chronic and progressive. In the larger proportion of cases the early symptoms of the disease are insidious. The patient begins to notice that when he arises in the morning, his knee-joint feels a little stiff and weak; the feeling of stiffness disappears after use. As time goes on there is added pain, felt at first when the patient has undergone unusual fatigue in walking or the like. In the meantime the knee-joint may be slightly swollen, and show some periarticular thickening, or the presence of a small amount of serous exudate. The diminution of function is progressive, and after a time causes serious disability.

In the cases attended by bony absorption of one or other condyle there will be produced a position of genu varum, or in other cases of genu valgum. In some, limitation of flexion will be very marked, and complete extension is usually impossible. In those cases attended by marked effusion into the joint a general relaxation of the ligaments produces a weak and wobbling knee, such that these individuals are obliged to wear some form of supporting apparatus in order to get about. The more profound the gross changes in the joint, the more serious the disability and the greater the pain, both spontaneous and on motion. In the latter stages of the disease the disability is increased by very marked atrophy of the muscles of the thigh, such that the patients suffer, in addition, from weakness of the limb due to this cause. Here, as in other joints, the advance of the disease, though progressive, is interrupted in many instances by intermissions and exacerbations. In the cases followed by much fibrous thickening and a tendency toward ankylosis, the bone changes may be slight or long delayed. In certain cases, notably those attended by hypertrophy of the synovial fringes and by the formation of new bone at the borders of the joint, such synovial fringes may undergo fibrous degeneration, or become the seat of the formation of cartilage or of new bone; and these fringes, or the nodular exostoses, may be broken off and continue to exist as free bodies in the joint. Such bodies may consist of fibrous tissue, of cartilage, or of bone, or of combinations of these ingredients. The body may have as a nucleus cartilage covered by bone, or bone as a nucleus covered by cartilage. Such bodies vary in size and number. They may be solitary, often they are multiple, and even hundreds may be present in the same joint. In size they vary from minute fragments to masses as large as the last joint of a man's thumb, or even larger. In these cases there may be produced the additional symptom of locking of the joint during use by the interposition of one of these floating bodies between the articular ends of the femur and tibia.

Diagnosis.—From what has preceded, it may now be understood that in well-marked cases of arthritis deformans of the knee the picture, though a varied one, is easily recognized. It is only in the cases which begin acutely, or in the early stages of those cases which closely resemble an acute attack of rheumatism,

or in those attended by fibrous thickening of the periarticular structures without much bony change, where any difficulties in diagnosis are likely to occur. *Time, the X-rays, the absence of the signs of acute inflammation, absence of suppuration and absence of the production of cold abscesses,* and aspiration of the fluid contained in the joint, with inoculation experiments, are usually sufficient to establish the nature of the condition. One of the early signs present in many cases and due to a roughening of the cartilaginous surfaces, together with changes in the synovial membrane, is *a palpable and even audible creaking* upon making passive or active motions in the joints. While there is nothing absolutely characteristic about this sign, yet *its presence in but a single joint,* such as the knee, together with a history of chronic joint disturbances, is strongly suggestive of arthritis deformans. Many of the diagnostic signs of the condition are visible upon inspection and upon palpation, though it may be readily understood that they will vary a good deal in different cases. The deformity of the joint, the atrophy of the muscles, the generally fusiform, or bulbous, or irregular shape of the swollen joint, the presence of creaking, the laxity of the ligaments in cases where much effusion exists, the bony grating in the later stages, are all readily recognizable. The condition of *chronic arthritis deformans* can usually be distinguished from *the arthropathies of tabes dorsalis* by the absence of the characteristic signs and symptoms of the latter disease, and by the more rapid and more destructive nature of the joint lesion in tabes, together with the absence or only trifling amount of pain, while the gross lesions are readily recognized as being excessive. Still, it is to be borne in mind that *typical arthritis deformans may also occur,* as I have seen in several instances, *in cases of tabes* which ran their course slowly and progressively and not at all in the manner usual in tabetic joints.

Treatment.—Suitable treatment: support of the limb, massage, baths, hygienic measures, avoidance of overfatigue in the joint, *without,* however, *keeping it too quiet,* a moderate amount of exercise being beneficial, may render these patients fairly comfortable and may delay the progress of the lesion; but the changes in the joint structures being of a distinctly organic character, cure is impossible.

Course.—The course of the disease is usually prolonged over many years. In a number of instances coming under my own care, where the deformity has been excessive, consisting in some cases of ankylosis with partial dislocation backward of the tibia due to the prolonged action of the ham-string muscles and attended by great disability, pain, and discomfort, and in others with greatly relaxed ligaments, I have resected these knees with the most gratifying results to the individual. It is to be borne in mind *that tabetic joints of the Charcot type, or even joints resembling closely arthritis deformans in tabetic individuals,* do *not,* as a rule, *get bony union* between the tibia and the femur, as I have learned in one case by unfortunate experience. Still, even this patient, by wearing a suitable splint, was able to get about with a greater degree of comfort than before the operation.

FLOATING BODIES IN THE KNEE-JOINT

While floating bodies in the knee-joint, consisting of bone, cartilage, or fibrous tissue, cannot be described as a pathological entity, since such bodies may form in the presence of a variety of conditions, yet a description of the symptoms produced by such bodies constitutes a more or less typical picture. Such free bodies in the knee are observed, as already stated, in arthritis deformans, and also under irritative conditions, local or general, in the knee, attended by hypertrophy of the synovial fringes, with the deposition of masses of cartilage in such fringes, which break off and thus become floating bodies. One sees such lesions accompanied by a chronic serous synovitis, and sometimes the removal of the floating body permits the joint to return to a normal state. Trauma with fracture of the semilunar cartilages, or resulting in separation of a portion of cartilage from the tibia or femur, is one of the frequent causes of the condition in young people. In other cases, however, we often find cartilaginous or bony masses in a joint where there has been no history of injury, or of any previous serious joint disturbance. I saw such a case less than a month ago in a young man of twenty-three, who had never injured his knee, but had observed about a year previously the presence of a free body which moved about in the front of the joint, and occasionally getting caught beneath the patella, or between the femur and tibia, caused severe pain or locking of the joint. The body was about the size of a small almond. The amount of synovitis in this case was very slight indeed. The occurrence of these bodies in arthritis deformans has already been noted.

Signs and Symptoms.—The signs and symptoms accompanying the floating bodies of arthritis deformans are simply those of that disease. When they occur in otherwise relatively healthy joints the symptoms are those produced by the *locking of the joint*, or getting the floating body caught beneath the patella. Such accidents are attended by more or *less severe pain* and are followed by a *mild grade of serous synovitis*, which becomes chronic and may finally eventuate in a *serious weakening of the ligaments* by stretching, unless the floating body is removed. The amount of pain caused in these cases by a floating body varies greatly. In the case spoken of in a preceding paragraph the patient suffered only trifling inconvenience, and had made the diagnosis himself by feeling the foreign body slipping about on either side of the patella, or sometimes in the quadriceps bursa. *In other cases*, notably those in which several bodies of considerable size have been present, the symptoms have been serious, the amount of pain and the effusion and relaxation of the ligaments marked. The *pain* attending the *bone-locking of the joint was excruciating*, so that in some of these cases the patients have fallen to the ground. In one or two, upon which I have operated soon after the onset of an acute synovitis, which followed the locking of the joint, the exudate has contained a little blood. The diagnosis of floating bodies in the joint is to be made by the history, by the accompanying synovitis, and by feeling the body with the fingers. *Unless* such bodies contain

calcareous matter or bone, they will not, as already stated several times in this book, *cast a shadow* visible in an X-ray picture.

The characters of hysterical joints have already been sufficiently described under Traumatic Hysteria in Vol. III and Vol. I.

ARTHROPATHIES OF THE KNEE-JOINT IN TABES DORSALIS; LOCOMOTOR ATAXIA; CHARCOT'S JOINT

The knee exhibits pathological changes in the course of *locomotor ataxia* more often than any other joint. The joint lesions may be divided into two groups. In the *first* group the joint disturbance often occurs quite early in the disease and is of a very slowly progressive character. It may last for many years without very seriously limiting the function of the joint, and without marked gross pathological changes in the joint structures, other than relaxation of the ligaments and the dilatation of the joint capsule. The *relaxation of the ligaments* produces in time more or less marked hyperextension of the knee-joint while the patient stands erect, a marked degree of *genu recurvatum.* While these disturbances of the knee in the course of locomotor ataxia are, in my belief, caused by repeated slight traumatisms to the knee, yet the results of such traumatisms are more serious than is the case with normal individuals. Following a slight injury or strain of the knee-joint, to which these patients are frequently exposed on account of the loss of perfect control of the extremities, a serous synovitis of the knee develops, usually *without* any very marked symptoms of *pain* or discomfort, and unless the patient sees a physician at once his attention may be and often is first attracted to the condition of the knee by observing that it is swollen. Upon presenting himself, it will be found that the knee is quite markedly distended with fluid. Under ordinary conservative treatment the effusion will frequently disappear in the course of a fortnight or a month, but no sooner does the patient again use the limb to the extent of fatigue, or receive another slight traumatism, than the synovitis recurs. Again under treatment it disappears, and again recurs. This condition goes on for years, the ligaments gradually becoming more and more relaxed until the joint is seriously weakened, and as one watches one of these patients walk it might be expected that any moment he might get a dislocation of the knee. Such, however, I have not observed. The degree of genu recurvatum is steadily progressive, or in some cases genu varum, or genu valgum upon one or both sides, may develop, and in these the patients are very much crippled.

I have had one of these cases under observation for more than ten years, and have aspirated his joint with good results on several occasions, and once washed it out with carbolic acid with temporary improvement. The fluid, sooner or later, always returns, and his condition is now distinctly worse than it was five years ago. He is still able to get about and has no pain, but his knee-joint is very much weakened.

In a *second* group of cases which it is said may follow the form just described

if neglected, or may occur suddenly and independently, *the joint lesion is of a much more serious character.* The essential lesion is a trophic disturbance of the bones and also of the soft parts entering into the joint. There is a rarefying osteitis developed in the tibia and femur, more commonly in the latter, which may in certain cases result in spontaneous fracture, or in others in the typical *destructive joint lesions* about to be described. The patient, having been the subject of a chronic and recurring synovitis, or without such a history, suddenly develops a marked effusion into the knee-joint. The ligaments become greatly relaxed, so that sometimes in the course of a few weeks or months dislocation of the joint occurs, or a flail-like joint, such that the knee may be moved freely in all directions, even to the extent of approximating the toes to the groin, and that without causing the patient any special pain or discomfort. Accompanying the relaxation of the ligaments, the *bones* entering into the joint are rapidly and somewhat irregularly *eroded.*

FIG. 214.—CHARCOT'S KNEE-JOINT OF THE DESTRUCTIVE TYPE IN A CASE OF FAR-ADVANCED LOCOMOTOR ATAXIA. (Case of the late Dr. W. J. Vought.)

That portion of bone, whether it be a condyle of the femur or the articular surface of the tibia, which is more greatly changed by the softening process, is *rapidly worn away,* so that considerable *loss of substance* occurs in the head of the tibia, or in one or other, or both the condyles of the femur. The condition may be so rapidly progressive that the *joint* is practically *disintegrated* in the course of *weeks or months.* All these changes occur without any signs of acute inflammation. The skin over the joint remains white, there is not necessarily any fever, acceleration of pulse-rate, or leucocytosis. The diag-

nosis is, of course, extremely simple in these cases. The patients are the victims of well-marked locomotor ataxia, and whereas the *first group*, characterized by the *chronic serous synovitis*, may occur *very early* in the disease, the later and *destructive types occur*, as a rule, only when the *disease is well advanced*. If, as sometimes happens, these joints become the seat of *pyogenic infection, the life of the individual* is very rapidly *destroyed*, unless they survive amputation. In a smaller proportion of cases in addition to the destructive process, there is the formation of osteophytes and of masses of cartilage within the joint, together, in some cases, with a marked papillary thickening of the synovial membrane. *This* portion of the *lesion* is, in my experience, the *exception rather than the rule*.

Signs and Symptoms.—The signs and symptoms of these neuropathic destructive lesions of the knee are quite characteristic. The entire limb as far as the ankle is usually swollen, it may be the swelling of a soft edema, or, on the other hand, a brawny induration. The signs of *acute inflammation are absent*. Upon making passive movements of the joint *bony grating* can usually be appreciated, and the joint can be moved into all sorts of abnormal positions, and all this without causing the patient notable pain. Upon *palpating* the knee-joint, the presence of *loose bodies* consisting of the separated portions of joint cartilage, of *fragments of bone* broken off the tibia or the femur in the process of disintegration, and sometimes of other loose masses of cartilage resembling in form the ordinary rounded or ovoid floating bodies observed in the knee under other conditions may be detected. With these local conditions the other typical signs and symptoms of tabes dorsalis are to be observed. It should be borne in mind that these *destructive lesions* may take place with *great suddenness*, so that the knee-joint may be totally disintegrated in a surprisingly short time. In the later stages *spontaneous fractures* of the tibia and femur are not uncommon. As already stated, group one of tabetic joints, characterized by chronic synovitis and relaxation of the ligaments, may run a very protracted course without seriously crippling the individual, nor in any way endangering his life. Such is, however, not the case with the destructive lesions just described. These patients do not, as a rule, long survive, though successful amputations of the thigh have been reported.

POPLITEAL ANEURISM

A SWELLING IN THE COURSE, OR OVERLYING A LARGE ARTERY, SHOULD ALWAYS BE REGARDED AS A POSSIBLE ANEURISM, AND SHOULD NOT BE INCISED UNTIL THE SIGNS OF ANEURISM HAVE BEEN SOUGHT FOR WITH CARE.

In no part of the body does this ancient rule of surgery apply with greater force than in the popliteal space.

Anatomical Remarks (*Adapted from Gray's Anatomy*).—The popliteal space occupies the lower third of the thigh and the upper fifth of the leg. It extends from the aperture in the adductor magnus to the lower border of the popliteus

muscle. The space has the form of a lozenge. It is widest at the back part of the knee-joint and deepest above the articular end of the femur. It is bounded externally, above, by the biceps, and below by the plantaris and external head of the gastrocnemius. Internally, above the joint, by the inner ham-string muscles, the semimembranosus and semitendinosus, gracilis, and sartorius. Below the joint by the inner head of the gastrocnemius. The floor of the space is formed by the lower part of the posterior surface of the femur, the posterior ligament of the knee-joint, and the upper end of the tibia, and by the fascia covering the popliteus muscle. "The entire space is covered in by the fascia lata. The space contains the popliteal vessels and their branches, the termination of the external saphenous vein, the internal and external popliteal nerves and their branches, the small sciatic nerve, the articular branch from the obturator nerve, a few small lymphatic glands, and a considerable quantity of loose adipose tissue." This tissue continues to contain fat even in states of marked emaciation.

The Popliteal Artery.—The continuation of the superficial femoral commences at the termination of the latter, at the opening in the adductor magnus, and passes obliquely downward and outward to the lower border of the popliteus muscle, where it divides into the anterior and posterior tibial arteries.

Relations of the Structures Contained in the Popliteal Space.—The internal popliteal nerve descends in the middle of the space and is quite superficial, crossing the artery from without inward in its downward course. The external popliteal nerve lies close to the tendon of the biceps muscle on the outer wall of the space. Somewhat more deeply and in the bottom of the space there lie the popliteal artery and vein; the vein lies superficial and a little external to the artery, to which it is firmly attached by dense fibrous tissue. In a certain proportion of cases the vein may lie to the inner side, or there may be two veins, one on either side of the artery, and such veins may here be connected by short transverse branches. Of the three structures, nerve, vein, and artery, the last is the most deeply placed. It lies from above downward in close contact with the femur, the posterior ligament of the knee-joint, and the popliteus muscle. The artery is covered superficially by the semimembranosus muscle, in the middle of its course by a quantity of fat, and below is overlapped by the gastrocnemius, plantaris, and soleus muscles, the popliteal vein and the internal popliteal nerve. The vein, as stated, lies superficial to the artery and in the upper part of the space to the outer side. In the lower part of the space it crosses the artery and comes to lie upon the inner side. The popliteal nerve is, as stated, more superficial and external; below the joint it crosses the vessel and comes to lie upon its inner side. Laterally the artery is bounded by the muscles which are situated on either side of the popliteal space.

The popliteal artery may be tied in any part of its course, though its ligation is easier in the upper and lower parts than in the middle, where it is more deeply placed.

Occurrence, Etiology, and Course.—While traumatic aneurism of the popliteal is rare, the spontaneous variety is quite frequent, aneurisms of this vessel constituting about one third of all the aneurisms of the peripheral vessels. Thus in Crisp's statistics of 551 aneurisms, 137 were of the popliteal artery. Any portion of the vessel may be the seat of aneurism, though the upper and lower parts are more often affected than the middle. The aneurismal sac may develop upon any aspect of the trunk, anterior, posterior, or lateral. The aneurism is most commonly of the sacculated variety.

FIG. 215.—POPLITEAL ANEURISM.
(Service of Dr. F. W. Murray, New York Hospital.)

Various causes have been assigned for the frequent occurrence of aneurism in this situation. Among others it has been supposed that the motions of flexion and extension of the knee-joint may compress or stretch the vessel. Certain it is that aneurisms in this situation are more frequent among those who do hard physical labor. Here, as elsewhere, atheroma of the artery and endarteritis due to any cause, and notably to syphilis, are present in a large proportion of the cases. Alcoholism, gout, and rheumatism are believed to be predisposing causes, their influence in the production of endarteritis being generally recognized.

The course of aneurism of the popliteal is toward steady growth with final rupture, either subcutaneously or through the skin, with the production of gangrene of the extremity, or of fatal hemorrhage. If the aneurism grows forward it may erode the condyles of the femur and rupture into the knee-joint.

Varicose aneurism and aneurismal varix are extremely rare in the popliteal space.

Symptoms.—The symptoms of popliteal aneurism at the beginning of the disease are usually not marked. The patient complains of moderate pain, usually believed to be rheumatic, referred to the knee-joint, with slight lameness

and limitation of flexion and extension at the knee. As the sac increases in size there is added pain of a more severe character, radiating downward into the leg and foot, in addition to which there may be paresthesiæ referred to the same regions. The nerve disturbances are due to pressure upon the nerve trunks of the popliteal space. When the tumor has reached a certain size, pressure upon the vein will cause congestion and edema of the extremity, and still greater pressure may produce thrombosis and obliteration of the popliteal vein, sometimes followed by gangrene of the extremity.

The size of the aneurism before it produces marked symptoms varies somewhat. In the end stages it may occupy the entire popliteal space, but when first seen by the surgeon it may be only the size of a goose egg or of a small orange. In a certain proportion of cases, portions of the clot contained in the sac may get into the caliber of the vessel and cause solitary or multiple embolism of the tibial arteries or of their branches, with the production of gangrene of a portion or the whole of the extremity.

The ordinary signs of superficially placed aneurisms are present. The tumor is smooth and rounded, pulsation may be visible. The consistence of the mass is elastic or fluctuating. It exhibits *expansile pulsation*. Pressure upon the femoral in the groin causes cessation of the pulsation, and in some cases *diminution in the size of the tumor*. The pulsation of the arteries at the ankle, dorsalis pedis, or posterior tibial, is delayed, and is less marked than upon the sound side. This delay and enfeeblement of the pulse may be demonstrated by means of sphygmographic tracings. The tumor may be made to increase in size by constricting the limb below the aneurism. *Auscultation* with the stethoscope reveals a characteristic whirring or blowing murmur over the tumor. It is to be borne in mind that pulsation and murmur may be weak, or absent, in case the communication between the artery and the sac is very small, or if the sac itself is more or less completely filled with firm clots. The occurrence of subcutaneous rupture will be followed by extensive extravasation of blood into the surrounding tissues up and down the limb, with pain, great swelling, and if, as is commonly the case, there is pressure upon the popliteal vein, causing obliteration of its lumen, there will be sudden marked disturbances of circulation in the foot and leg, rapid swelling, and frequently gangrene. External rupture is followed by a single fatal hemorrhage or by repeated hemorrhages which finally end the patient's life.

Differential Diagnosis.—In the differential diagnosis of popliteal aneurism we have to consider acute inflammatory processes such as abscesses in the popliteal space, whether from suppuration of the popliteal lymph nodes or from some other cause. Cystic formations in this space, frequently connected with the popliteal bursa, occasionally lipomata, and, lastly, highly vascular sarcomata of this region. By carefully attending to the history and by seeking for the characteristic signs of aneurism, we are usually able to make a definite diagnosis. In the history of those cases of superficial aneurism which have

been incised by surgeons in the past, upon the supposition that the tumor was of some other character, a careful examination for the elimination of aneurism has rarely been made. While cysts and lipomata of the popliteal space may give rise to pulsation, it is not of an expansile character. Transmitted pulsation can usually be differentiated from the pulsation of aneurism by grasping the tumor mass deeply upon either side, when it will be discovered that the characters of true expansile pulsation are absent. If the tumor can be lifted a little away from the artery the pulsation ceases. In all the conditions which may be mistaken for aneurism, the pulsation of the vessels at the ankle will be found alike upon the two sides, nor do these tumors diminish in size when the femoral is compressed. The pulsating sarcomata are usually firmer than an aneurism and do not give the signs of elastic fluctuation characteristic of the presence of fluid. Moreover, they do not to the same extent diminish in size when the circulation above is cut off through the main vessel of the limb. The X-rays, in cases of doubt, may aid in the diagnosis, since the sarcomata of this region will usually have arisen from the femur or tibia, and will show in an X-ray picture loss of substance in the bone, the formation of bony plates, and other changes which do not occur in aneurism. Moreover, in some of these cases it may be possible upon palpation to detect the irregularities in the contour of the condyles of the femur.

THE DISEASES OF THE BURSÆ IN THE VICINITY OF THE KNEE

The bursæ, constant and inconstant, in the vicinity of the knee-joint are very numerous. The situation of those upon the anterior and posterior aspects of the knee are shown in Figs. 216 and 217, from Merkel's "Topographical Anatomy." A moderate number only of these bursæ are of distinct surgical interest. Of these the most important are the bursæ overlying the patella in front, the bursæ overlying and beneath the ligamentum patellæ, and posteriorly, the popliteal bursa. The inflammations of the bursæ resemble those observed in serous membranes. The exudate may be serous and the condition acute or chronic, there may be in the chronic cases a proliferating bursitis, with the formation of papillary outgrowths from the wall of the bursa, such that the cavity of the bursa may be more or less completely filled with papillary masses and strings of fibrous tissue. Acute suppurative inflammation is also observed in these bursæ, as the result of infected wounds, or of an extension of a suppurative process to the bursa from surrounding structures—furuncles, subcutaneous abscesses and the like.

Tuberculous Inflammation of the bursæ is also observed. In addition to the bursæ observed in the ordinary anatomical sites, cystic tumor formations are occasionally seen in other situations, usually in places which have undergone long-continued mechanical irritation. These are believed to have a similar origin to some of the cases of ganglion observed near the wrist-joint—namely, to the colloid degeneration of connective tissue and of fat. This view

of the causation of these cystic growths has been studied, and it is believed demonstrated, by the researches of Ledderhose,[1] Thorn,[2] and Franz.[3]

Tumors of the Bursæ of the knee have been observed in a very few cases, and chiefly in the prepatellar bursa. Among the varieties described may be mentioned sarcoma, myxoma, and endothelioma. They are extremely rare and scarcely require further mention.

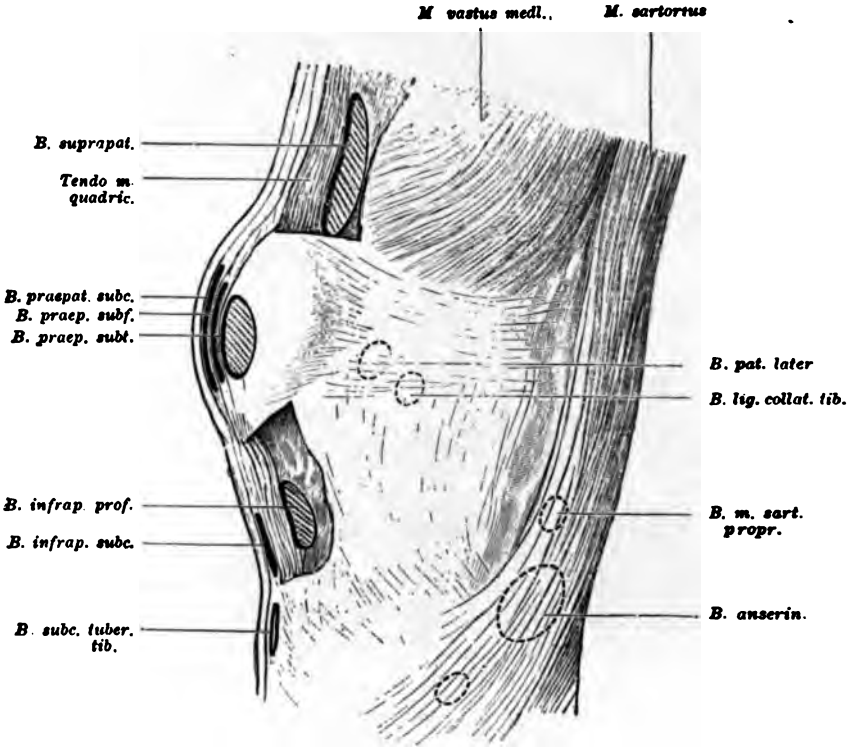

Fig. 216.—The Bursæ of the Knee upon the Anterior and Inner Aspect of the Limb. (After Merkel.)

Tuberculosis of the Bursæ may originate in the bursa itself, or occur as the result of secondary involvement of the bursa from the neighboring soft parts, or the bones or joints.

The Prepatellar Bursæ.—Three bursæ are described as occurring with more or less regularity over the patella and beneath the skin. They are, a *subcutaneous bursa*, *subfascial bursa*, and a *subtendinous bursa*. The subcutaneous bursa lies in the deeper layers of the subcutaneous tissues. The situation of this bursa is not entirely regular. It may be centrally placed, or overlie either of the four quadrants of the patella. In size, it varies from 3 to 4 cm. in diameter. The bursa is present in eighty-eight per cent of adult individuals (Bize, quoted by Merkel). It is not present in children. Pyogenic infection

[1] Ledderhose, *Deutsche Zeitsch. für Chir.*, xxxvii. [2] Thorn, *Archiv für Klin. Chir.*, lii, 593.
[3] Franz, *Archiv für Klin. Chir.*, lxx, 953.

of this bursa is often attended by diffuse suppuration of the skin and subcutaneous tissues on the front of the knee-joint.

The Subfascial Bursa lies in the loose connective tissue between the fascia lata and the tendinous expansion of the quadriceps. In situation it resembles the subcutaneous bursa; in size it varies from an inch to two inches, or thereabouts, in diameter. It is constant in ninety-five per cent of adults and absent in children. It may communicate with either or both of the other bursæ in this situation.

The Subtendinous Bursa lies between the tendinous expansion of the quadriceps and the periosteum of the patella. It is usually smaller than either of those previously described. It is present in eighty per cent of adults and is absent in children. These three bursæ are developed only after the individual has used the knee actively and for a considerable time. They are, as stated,

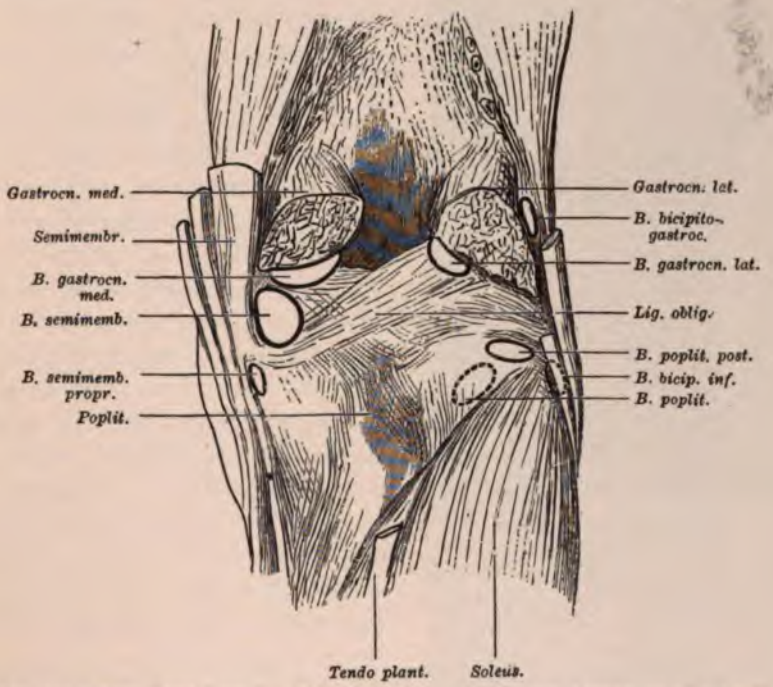

Fig. 217.—The Bursæ of the Knee upon the Posterior Aspect of the Limb. (After Merkel.)

not observed in children. We have already described in a previous section the acute inflammations of the prepatellar bursæ, the result of subcutaneous violence attended by a serous or bloody exudate. It is usually impossible before the time of operation, and sometimes not even then, to distinguish which of these bursæ are involved, and it is to be borne in mind that they may all communicate, and that when inflamed a single large sac may be produced, such that the separation or dissection of the several bursæ is not possible.

Acute Pyogenic Infection of the Prepatellar Bursæ.—Acute suppurative inflammation of the prepatellar bursæ may result from infection of open wounds of the skin over the patella, or, as a secondary infection by continuity of structure, from furuncles, abscesses, or phlegmonous processes of the skin and soft parts of the front of the knee-joint.

The signs and symptoms of acute prepatellar bursitis are, the formation at the site of the bursæ of a rounded, smooth, tense, fluctuating, tender, painful swelling covered by reddened and edematous skin. The constitutional signs and symptoms of sepsis are more or less marked. The character of the exudate is easily determined by the use of an aspirating needle. In not a few instances the suppurating process invades the surrounding soft parts of the limb, and may present itself as a diffuse cellulitis or, in streptococcus infections, as a phlegmonous necrotic process. As a rule, the diagnosis of the condition presents no difficulties whatever. Only a very *inexperienced examiner* could mistake any of the varieties for an *affection of the knee-joint itself*. I have occasionally seen this error made, however, by young members of the house staff in hospitals. The swelling is evidently a superficial one. The patella is not elevated, nor are the signs of effusion into the knee-joint, floating patella, etc., to be observed. It is to be borne in mind, however, that synovitis of the knee and prepatellar bursitis may coexist. The treatment of these conditions is that of suppurative inflammations wherever situated.

Fig. 218.—Fibroma of the Front of the Leg of Ten Years' Duration Resembling a Chronic Bursitis. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

Chronic Serous Prepatellar Bursitis (*Housemaid's Knee*).—A chronic serous inflammation of one or other or all of the prepatellar bursæ is most often observed among those whose occupations necessitate prolonged labor in a kneeling position: housemaids, carpet layers, scrub women, and the like. In the various manipulations necessary in these occupations the individual must bend far forward; and thus the front of the patella is repeatedly brought into contact with the floor. The chronic irritation of the bursa leads to a serous effusion. A single acute attack of bursitis, thus produced, usually recovers spontaneously; but if the traumatisms are repeated indefinitely, the disease becomes chronic. The character of the exudate is sometimes clear synovial fluid; some-

times it contains an admixture of blood, or of yellowish or brownish blood pigment. If the disease is untreated, the wall of the bursa becomes notably thickened, and the sac may reach a considerable size, in some cases being as large as an egg or as a small orange. There is usually a history of repeated attacks of acute inflammation, during which the rounded, fluctuating mass increases in size and becomes more tense and painful. The seat of the tumor, its configuration, and the physical signs as described, usually enable the surgeon to make a probable diagnosis at sight.

In some of the cases a proliferating inflammation of the lining wall of the sac occurs, with the formation of diffuse nodular or papillary thickenings and of fibrous cords, stretching from one wall of the sac to the other. In this way a tumor of considerable size and almost solid consistence may be produced. In these cases, instead of elastic fluctuation the tumor may feel quite hard, as though it were solid.

The amount of discomfort varies a good deal in different cases. In many it is trifling, and the patient may come to the surgeon for advice only when, as the result of an injury the bursa becomes infected with all the signs and symptoms of an acute suppurative process.

Fig. 219.—Tuberculous Prepatellar Bursitis. (New York Hospital collection, author's service.)

The treatment of all these forms is, in my experience, *excision*, rather than *incision* of the sac, nor have I a high opinion of attempts to obliterate the cavity by injections of caustics or other irritating fluids.

Tuberculosis of the Prepatellar Bursæ.—Tuberculosis of the prepatellar bursæ is not very rare. The bursa may become affected primarily, or secondarily, from disease of the underlying patella. In the cases I have seen, a considerable tumor mass was formed, and these patients have rarely come under observation until the disease had existed for months or years, and had formed typical tuberculous sinuses, discharging more or less thin, purulent fluid, or cheesy material. In these cases the cavity of the bursa is apt to become more or less completely filled with tuberculous granulation tissue, or fibrous cords and masses containing trabeculæ and cavities filled with tuberculous granulation tissue or cheesy material. The disease is usually attended by more or less marked pain and discomfort upon using the limb; there is usu-

ally tenderness on pressure. If sinuses form, a mixed infection with pyogenic microbes may complicate the condition and change the picture to one of an acute suppurative process. Usually the diagnosis of tuberculosis will not be made until such time as the bursa is operated upon; though tuberculous lesions in other parts of the body may be suggestive. In those cases first seen after sinuses have formed, the appearances are characteristic of tuberculosis, and the character of the discharge and of the sinuses is more or less typical.

The Subcutaneous Bursa Over the Tuberosity of the Tibia.—This bursa lies over the tuberosity of the tibia, and usually extends upward a certain distance in front of the ligamentum patellæ. It is much more rarely the seat of inflammation than the prepatellar bursa, but is subject to the same conditions and its inflammation or infection is followed by signs similar to those just described.

The Infrapatellar Bursæ.—Three bursæ may occur in relation with the ligamentum patellæ. (1) *A superficial or subcutaneous bursa.* (2) A bursa may also occur in this region *beneath* the aponeurosis. This may communicate with one or other of the prepatellar bursæ, so that simultaneous inflammation of the two bursæ may occur with the formation of a double sac and a double swelling.

(3) Beneath the patellar tendon and superficial to the tibia, in close relation to the capsule of the knee-joint, a bursa occurs, which, however, does not communicate with the joint cavity except in very rare cases. *Only the last mentioned* of these three is of distinct surgical interest. It is the seat of the same inflammatory processes which occur in other bursæ, and also not very rarely of the condition known as EXOSTOSIS BURSATA in which there is a growth from the anterior surface of the tibia, forward into the cavity of the bursa *of masses of cartilage,* sometimes covering a *bony nucleus.* These masses may break off and exist as free bodies in the bursal sac. As the result of the mechanical irritation produced by the pressure of the ligamentum patellæ such a sac may become inflamed and the seat of a serous synovitis. In these cases a fluctuating tumor lies beneath the ligamentum patellæ and usually *projects on either side.* Considerable functional disturbance of the knee-joint may result, the motion of flexion may become painful, and the larger the bursa grows the more will the motions of the knee-joint be interfered with. If a considerable quantity of fluid accumulates in the bursa, it will form two distinct rounded, fluctuating projections, one on either side of the ligamentum patellæ, and pressure upon one of the sacs will make the other larger and more tense. The diagnosis of this form of bursitis, when accompanied by the growth of bony nodules covered by cartilage, is sometimes aided by the use of the X-rays.

The Popliteal Bursa.—The most important bursa upon the posterior aspect of the knee is the popliteal bursa, which lies beneath the tendon of the popliteus muscle. It is constantly present and quite regularly communicates with the knee-joint. Such a communication is present at birth in about half the

cases. In one seventh of the cases in adults, the bursa communicates also with the tibiofibular joint (Fick). In some of the cases the bursa more or less completely surrounds the tendon of the popliteus muscle. Inflammations of the popliteal bursa may give rise to cystic tumors in the popliteal space of considerable size, such that when viewing the limb in the extended position the bursa may form a visible tumor in the popliteal space. Palpation of the bursa is, however, more readily made when the knee is partly flexed. The symptoms produced by the chronic serous inflammations of the popliteal bursa are chiefly mechanical. The individual feels a certain degree of discomfort when walking for long distances, and certain motions involving flexion of the knee-joint are made with more or less difficulty. Subjectively, there is a sensation of pressure and of tension which may, after prolonged muscular effort, increase to actual pain. As the tumor increases in size, flexion of the knee-joint becomes more and more interfered with, and these individuals may find themselves very uncomfortable if they keep the knee flexed for a considerable time. The diagnosis is to be made from the history of the above-described symptoms and from the presence of a rounded, sharply circumscribed tense and elastic tumor in the popliteal space. The mass is evidently deeply seated and immovable. It may be slightly tender on pressure. In certain cases associated with chronic serous synovitis of the knee this bursa may also be enlarged, and in some of these it is possible to get a sense of fluctuation between the knee-joint and the bursa. That is to say, when the fluid in the knee-joint is compressed, the tension of the bursa is increased and vice versa.

The differential diagnosis of this form of bursitis is not always entirely simple. Aside from popliteal aneurism already described, it is necessary to exclude true tumors of the popliteal space—lipoma, myxoma, and soft sarcoma. A tuberculous abscess in this region may also give rise to similar physical signs. In some cases the use of the aspirating needle will clear up the diagnosis. The physical signs of a lipoma in the popliteal space may be practically identical with those of a bursa. The sarcomata are likely to be mistaken for this form of bursitis only in their early stages. They do not long remain sharply circumscribed, and their growth is usually fairly rapid. If such sarcomata have originated in the femur or the tibia, the X-rays may sometimes aid in the diagnosis. In a good many instances the actual condition will not be determined until an incision is made over the tumor for the purpose of removing it. It is to be borne in mind in regard to the treatment of these bursæ that since they often communicate with the knee-joint, irritating injections are not to be used.

Of the other bursæ on the posterior aspect of the knee, it may be said that inflammations of the bursa beneath the semimembranosus form rounded or ovoid tumors situated rather to the inner side of the popliteal space. From their position they may sometimes be differentiated from popliteal bursæ, since the latter usually occupy the outer half of the space.

SUPPURATIVE PROCESSES OF THE POPLITEAL SPACE

Acute abscess formation in the popliteal space is not exceedingly frequent. Such abscesses may arise from infection of the lymph nodes of the space from infected lesions of the foot and leg. As compared with suppurative inflammation of the lymph nodes of the groin, such abscesses are quite rare. Perforation of a bone abscess, in one or other of the condyles of the femur, may also cause suppuration in the popliteal space. In other cases an abscess may occur as the direct result of an infected wound of the ham. The signs and symptoms of popliteal abscesses are the usual ones of acute suppurative processes elsewhere—i. e., constitutional symptoms of sepsis more or less marked. Locally, the patient suffers intense pain referred to the posterior aspect of the knee, the limb is held in a position of moderate flexion; upon inspection there is localized swelling and upon palpation extreme tenderness. The skin may be reddened or not, according to whether the abscess has or has not approached the surface. The physical signs will, of course, vary somewhat in different cases. If the abscess arises in a lymph node, a circumscribed tender mass may be felt on deep palpation. If, on the other hand, the process is diffuse, the entire space may be occupied by a hard and brawny infiltration producing absolute fixation of the knee-joint, any motion causing extreme pain. Here, again, it is to be borne in mind that what appears to be a diffuse phlegmonous inflammation may be an aneurism, which has ruptured or is about to rupture, and due caution should be used to exclude an aneurism before an incision is made.

Chronic suppuration in the popliteal space is observed as the result of chronic osteomyelitis of the upper end of the tibia or the lower end of the femur, whether of a pyogenic or tuberculous character. Tuberculosis of the knee-joint also may give rise to a cold abscess in this region. The diagnosis of these conditions must be made from the history and from the local signs and symptoms of such processes wherever situated.

CHAPTER XXIV

TUMORS AND DEFORMITIES OF THE KNEE

TUMORS OF THE KNEE

The tumors of the soft parts in the vicinity of the knee-joint possess no individual peculiarities demanding attention. There occur here, as in other situations, a variety of new growths, both of the connective-tissue group and of those originating in the epithelial structures of the skin. Among the former may be mentioned lipoma, fibroma, myxoma, and sarcoma. Their characters are as elsewhere described. A rather rare tumor of the popliteal space is shown in Vol. I, page 283, a lipoma. The bursæ in the vicinity of the knee-joint are rare sites of tumor formation, as mentioned in Chapter XXIII. The tumors originating in the bones in the vicinity of the knee possess a greater interest. Those growing from the lower end of the femur have been described in a preceding section. A few of them may again be enumerated here. Among the benign tumors exostoses and combinations of bone with cartilage are not very rare. They take their origin, as a rule, from the line of the epiphyseal cartilage. These cartilaginous and bony tumors are not very rarely observed in children the subjects of rachitis, and may be said to be, to some extent, hereditary, since several examples are often observed in the same family. Here, as elsewhere, the tumor may be covered by a bursa the result of mechanical irritation, constituting the condition already mentioned of *exostosis bursata*. The purely cartilaginous tumors may also grow from the upper end of the tibia and the lower end of the femur. They are often multiple tumors, and may exist in many parts of the body in the same individual. The malignant forms of chondroma are occasionally observed in this region.

Malignant Tumors of the Knee.—We have already described the malignant tumors originating in the lower end of the femur. The same new growths occur in the upper end of the tibia, and here they possess the same pathological characters and the same tendencies to return and to destroy life, whether they originate in the one bone or in the other. Of the sarcomata arising in the tibia, however, it may be said that the prognosis following amputation of the limb through the middle of the thigh is better than after amputations done for sarcoma of the femur. The periosteal sarcomata are, as a rule, more malignant than those arising in the medulla of the bones. Next to the femur the tibia is more often the seat of sarcoma than any of the other long bones, and the new growth most often begins near the upper end of the bone. The central

sarcomata are more common than the periosteal forms. A large proportion of these tumors are of the giant-celled type. Here, as elsewhere, in a certain proportion of cases the appearance of the new growth follows immediately or remotely upon an injury to the bone. The disease may occur at any period of life, though the majority of cases occur before the thirtieth year. Although the prognosis following early amputation through the middle of the thigh is better than for similar disease in the femur, it cannot be said to be more than relatively favorable. Thus, of six cases reported by Coley and treated by amputation of the thigh, all but one died of early recurrences or of metastases. Coley reports several cases of cure following operation and the subsequent use of the mixed toxins of erysipelas and the Bacillus prodigosus. Among the cases of sarcoma reported by McCosh, *Annals of Surgery,* August, 1904, there were four cases of sarcoma of the leg originating in the bones. All were treated by amputation through the thigh. Of these one, a spindle-celled sarcoma, remained well for thirteen years. A second, giant and spindle-celled, remained five and one third years well. A third, spindle-celled, died six months after the operation, and the fate of the fourth, a giant-celled sarcoma, was unknown. I have had one case done five years ago, whom I believe is well, though I have lost track of him for the past year.

Diagnosis.—The early diagnosis of sarcoma of the tibia is not easy. When the tumor has caused a great enlargement of the bone with bony crackling, etc., the diagnosis is entirely simple, but in the early stages the symptoms are so indefinite that a very early diagnosis can scarcely be made except by operation. The patients complain of dull rheumatic pain, and later the upper part of the leg or the region of the knee becomes locally or diffusely swollen. In those cases attended by irritation of the knee-joint and a serous effusion the diagnosis of tuberculosis will often be made. In some instances the X-rays will furnish valuable aid, showing bony destruction, or an increase in the size of the bone with a thinning of the cortical layers and loss of the details of the cancellous structure. The subsequent history of these cases is the same dreary story which obtains of sarcomata in other regions. It is to be borne in mind that even after operation we may not be absolutely sure of a diagnosis. In a good many instances of tumor formation, more commonly originating in the soft parts than in the bone, a pathological diagnosis will be that of simple fibroma; and yet these individuals will subsequently suffer from metastases, showing the characters of spindle-celled sarcoma, or from local recurrences of a sarcomatous character.

Tumors of the Knee-joint Itself.—New growths originating in the synovial membranes of joints are rare. We have already mentioned the occurrence of cartilaginous and bony bodies free in the cavity of the knee-joint, but these are scarcely to be regarded as in the nature of true tumors. A very few cases of fibroma have been described as originating in the synovial membrane of the knee-joint. It goes without saying that cartilaginous and bony tumors arising in the articular ends of the femur or tibia may project into the knee-joint,

and, as elsewhere described, may be broken off and form loose intra-articular masses.

A peculiar condition of hypertrophic lipomatous degeneration of the synovial membrane occurs as a rare lesion and is known as *lipoma arborescens*. The entire synovial membrane of the joint is changed in such a manner that its surface is covered with sessile and pedunculated masses of fat, presenting a branching arrangement, from which the name of the condition is derived. The condition is one which gives a clinical picture resembling more or less the type of arthritis deformans without marked bony changes. The joint is diffusely swollen, and upon palpation the sensation derived is that the joint is filled with a soft material, which may give rise to soft crepitation upon palpation. It is rare that the diagnosis can be made positively until the joint is opened.

A very few cases of isolated LIPOMA of the synovial membrane of the knee-joint have been described. They are probably to be regarded as a prolapse of the fatty tissues of the knee, which may have a traumatic origin. (See also Internal Derangements of the Knee-joint.) The symptoms produced by these intra-articular tumors are partly those of a chronic arthritis, or of a chronic synovitis, accompanied by the presence of loose bodies in the joint.

DEFORMITIES OF THE KNEE

We have already spoken in many places of certain congenital or acquired deformities of the knee, the latter following injuries and diseases of various characters. We shall here confine ourselves to the deformities following poliomyelitis anterior in children, and to a brief description of bow-legs and knock-knee.

Poliomyelitis Anterior (*Infantile Paralysis*).—While the diagnosis of infantile paralysis in its early stages belongs rather to the domain of general medicine, a brief outline of the characters of the disease may not be out of place. The condition is one which occurs among children, usually under the age of four years. It is observed in epidemics and also in isolated cases. The onset is more common during the summer months. The infectious nature of the condition, if such it be, has not as yet been determined. The lesion is essentially a degeneration in the anterior cornua of the central gray matter of the cord and the lesion is of quite irregular distribution, though in most instances the motor symptoms are confined to the muscles of the lower extremity. There follow atrophy and degeneration of the ganglion cells and of the nerve roots and nerves, supplying groups of muscles. The affected muscles become paralyzed and undergo more or less complete atrophy, showing also the electrical reaction of degeneration. (See Injuries of Nerves in this volume.) The distribution of the palsies is quite irregular. Sometimes entire groups of muscles are involved, sometimes scattered single muscles here and there. In severe cases the nutrition of the entire limb is profoundly affected, so that the growth

of the bones is retarded. There is also in many instances a relaxation of the ligaments of the joints. Inasmuch as the onset of the disease is sudden and is attended by severe constitutional depression, sometimes by delirium and convulsions, the diagnosis in the early stages may not be correctly made. The disease may be mistaken for epidemic cerebro-spinal meningitis, for typhoid fever, or for some other acute infectious disease; but within a short time the general symptoms abate, and the paralysis of one leg, or of both legs, or of groups of extensor or flexor muscles in one or both legs or thighs, becomes manifest, and is soon followed by atrophy, by loss of tendon reflexes, and by changes in the electrical reactions of the muscles.

If untreated, or improperly treated, the unopposed contraction of certain groups of muscles produces deformities of the joints of one sort or another, depending upon what muscles are involved. In the knee-joint, if the extensor muscles of the thigh are paralyzed, the resulting deformity will be that of subluxation backward of the tibia, with abduction and external rotation. If the flexor muscles are paralyzed, there will be produced the condition of genu recurvatum, the amount of hyperextension of the leg and relaxation of the ligaments varying in different cases. Generally speaking, the diagnosis is entirely evident upon inquiring into the history and upon ordinary methods of examination, inspection and palpation, the electrical examination of the muscles, the contractures and the evident loss of power in the limb. (See also Foot and Ankle.)

Bow-legs (*Genu Varum*).—Certainly in the largest proportion of cases, if not in all, the deformity commonly known as bow-legs among children is due to rachitis. The softening of the bone, due to its imperfect nutrition, causes it to bend, partly as the result of weight bearing and partly as the result of muscular contraction, so that deformities of one sort or another occur in various parts of the body. In the lower extremities two types of deformity are observed—namely, an outward bowing of the femur and of the tibia with the production of bow-legs, or, on the other hand, the opposite type producing the deformity known as knock-knee or genu valgum. In bow-legs the deformity may be confined to the tibia and fibula and be a simple outward bowing, or bowing with an added anterior curvature, or there may be an outward and forward curvature of the femur alone, or combined with a similar deformity in the bones of the leg. The deformities may sometimes be observed even before the child begins to walk, and is usually associated with the other easily recognized signs and symptoms of rachitis. (See Vol. I.) In other cases, the deformity is not noticeable until the child begins to walk, and if untreated may go on increasing for a number of years, producing very marked deformities and disabilities. The children stand in an awkward way with the feet separated, and the gait in walking is clumsy, wobbling, and uncertain. The coexistence of coxa vara with rachitic deformities of the tibia and femur has already been mentioned, but it usually does not give notable symptoms of its own until the child has become adolescent. The character of the

deformities of the bone may be accurately represented by means of X-ray pictures.

The treatment of these conditions is partly by means of apparatus and partly by osteotomies upon the curved bones, as may seem to be necessary in the individual case. The diagnosis is, of course, readily made upon inspection. In a certain number of cases there may be a bow-leg deformity in one limb and knock-knee in the other.

Knock-knee (*Genu Valgum*).—Knock-knee is, among white children of American birth, less frequent than bow-legs, but among Italians and negroes it is seen with great frequency in the hospitals of the City of New York. The condition is one of angular deformity at the knee-joint, frequently associated with more or less marked curvature of the femur, and characterized by an undue projection downward of the internal condyle of the femur. When present upon both sides the child stands with its thighs together and its feet wide apart, producing the characteristic appearance called by the Germans X Bein. While in children the condition is regularly due to rachitis, in adults it may be due to deformities following fractures, or, as elsewhere described, to chronic disturbances of the knee-joints. It may also be due to the relaxation of the ligaments observed in infantile paralysis. The German writers, notably in Austria, describe a form of knock-knee which occurs in youths who are put at arduous occupations requiring the continued maintenance of the erect position for long periods. This group of cases is said to be most frequent among bakers, blacksmiths, waiters, and others who have to stand much upon their feet. Whether in these cases observed in adolescents the deformity has any direct relation to rachitis is not definitely known. The pathology of the condition has given rise to a good deal of discussion, but from a practical point of view I think it is of very little moment. The symptoms produced by marked knock-knee deformity are, that the patient is obliged to assume an awkward position while walking. In order that the knees may not interfere, the thighs must be abducted, and the gait is a peculiar and unsightly one. The muscles of the limb are often imperfectly developed, and such individuals tire readily after muscular effort. Prolonged standing is not only fatiguing but sometimes painful. The diagnosis of the condition is to be made upon inspection, and requires no further comment. According to the degree of deformity and the age of the patient when first seen, the treatment of knock-knee is partly by mechanical support and apparatus, and partly by operative measures upon the bones.

Simple or cuneiform osteotomy above the condyles of the femur are the regular procedures, the former being usually sufficient.

CHAPTER XXV

INJURIES OF THE LEG

INJURIES OF THE SOFT PARTS

Injuries of the muscles, the nerve trunks, the tendons and the blood-vessels of the leg, the result of incised, stab, or gunshot wounds are much less frequent than similar injuries in the upper extremity. They do not require a special description in this place. Some of them will be spoken of incidentally in the course of the following chapter, and the same may be said of *contused and lacerated wounds from blunt violence with complications.* Such injuries of the leg, though frequent, are rarely confined to the soft parts alone, but, usually involve also fractures of the bones, and in many cases are to be regarded rather as complications of such fractures.

Wounds of the subcutaneous veins of the leg are attended by venous hemorrhage of a more or less brisk character, according to the size of the vein wounded. The diagnosis of such injuries is to be made upon inspection. If the wounded vein be in a varicose condition, the hemorrhage, if untreated or improperly treated, may be serious or even fatal.

Isolated, incised, or stab wounds of the anterior or posterior tibial arteries are extremely rare. When they occur, the diagnosis is to be made from the anatomical site of the wound and from the character of the bleeding. Isolated gunshot wounds of the tibial arteries are rare. As a rule, the injury is complicated by fracture of one or both bones of the leg, or by extensive laceration of the muscles. A case of this character, so far as the history relates, not associated with fracture, and of distinct historical interest, is that of the Commanding-General of the Confederate Army at the battle of Shiloh, fought on April 6, and 7, 1862. The general was wounded in the leg by a rifle bullet, but continued in the saddle, and for a time gave orders to his officers. He was, however, observed to become pale, and was taken to a place of safety, where he bled to death in a few minutes. The history states that the bullet had cut an artery in his leg. He lived only a short time after he was shot. In the reports of wars, the gunshot wounds of the leg are usually those associated with fractures of the bones and in these the artery may be wounded by the bullet itself or by the bony fragments. In the Civil War the mortality following gunshot fractures of the leg was 26.4 per cent. In the Spanish-American War 146 such cases were reported, 6 died, the death rate being 4.1 per cent. In 15 cases amputation of the leg was done with 2 deaths. Gunshot fractures of the bones of

the leg will be mentioned incidentally when speaking of fractures of the tibia and fibula.

In a few cases traumatic aneurism has followed injuries of the tibial vessels. Such injuries have been stab and gunshot wounds, or in the larger proportion of cases the vessel has been wounded in fractures of the bones of the leg. Here, as elsewhere, the formation of a primary arterial hematoma may take place at once, or in other cases, weakening of the arterial coats may give rise to a traumatic aneurism after days or weeks. (See also Aneurisms of the Leg.)

The symptoms of injuries of the nerves of the lower extremity have been elsewhere described. Division of the tendons as isolated injuries in the leg are far more rare than is the case in the forearm, and unless such large tendons as the tendo Achillis, the tibialis posticus or anticus were injured, the resulting disability would usually be less if the tendon were not sutured, than is the case with the hand, since in the foot no such fine movements are necessary for the functional use of the limb as in the upper extremity. (See, however, Paralytic Deformities of the Foot and Ankle.)

FRACTURES OF THE BONES OF THE LEG

Fractures of the bones of the leg are among the most frequent of all fractures. They occur more often among men than among women; they are rare in childhood, and are most frequent during the active decades of life—namely, between the ages of thirty and sixty. During each of these decades they occur in almost equal numbers. In a general way it may be said of these injuries, that in most of them the diagnosis is readily made, though to this rule there are exceptions. In the cases in which the line of fracture lies close to or invades the joint, either the knee-joint or the ankle, the exact condition of affairs, in complicated and comminuted fractures, may be very hard to determine by ordinary methods of examination, and here, perhaps more than in any other region of the body, the X-rays are a very useful aid. The surgeon should, however, train himself not to depend too much upon the X-rays in the diagnosis of fracture, but to conduct his examination by ordinary methods with great care and to use the X-rays as a verification of his conclusion or as a correction. In difficult cases general anesthesia is very valuable, not only in diagnosis, but also as an aid in reduction and in sparing the patient pain. More important, perhaps, than the diagnostic value of the X-rays in the detection of fractures of the tibia and fibula is its use in enabling the surgeon to tell whether his efforts at reduction have been successful, and further, whether the apparatus which he has applied has maintained such reduction. For this latter purpose the X-rays are indeed invaluable, since, as has elsewhere been pointed out, the pictures may be taken through a fixed dressing of plaster of Paris, and will show under such circumstances the position of the bones, not quite as well as though the naked limb were placed upon the plate, but sufficiently well for the detection of displacements. Fractures of the tibia and fibula may occur at any

level. In the following description of the different types of fracture, I have followed the grouping of Dr. Stimson in his classic work on "Fractures and Dislocations."

Fractures of the Upper End of the Tibia and Fibula, or of the Tibia Alone

Fractures of the upper end of the tibia are very serious injuries, since in a large proportion of cases the fracture extends into the knee-joint; the resulting inflammation of the joint is often severe and prolonged, leading to more or less marked disability and stiffness of the knee; and further, the displacements, though slight, interfere with the mechanical arrangements of the knee-joint, so that permanent deformities (either knock-knee, or genu varum, or rotary displacements) may persist, or marked limitation of motion with corresponding diminution of function. Moreover, the upper end of the bone lies in close contact with the posterior tibial vessels, and in a number of reported cases these have been injured. The period required for union is also much longer than is the case with fractures of the shafts, and is stated to be on the average about four months.

The causes of fracture of the upper end of the tibia are varied. Such may be direct violence to the bone, such as from blows, the commonest cause of this description usually cited being the kick of a horse. In the fractures produced by indirect violence, the injury may result from a fall upon the feet, or by violent abduction or adduction of the limb. The line of fracture varies and may take almost any direction. It may be transverse, oblique, or in rare cases vertical. Comminuted fractures as the result of falls from a height may be attended by extensive crushing of the upper portion of the bone with separation of the condyles by the interposed fragment of the shaft. In the group of fractures caused by abduction or adduction of the limb the line of fracture is usually oblique, separating one of the tuberosities of the tibia from the shaft. The fracture of the tuberosity occurs upon the side toward which the limb is bent. The diagnosis of these fractures is frequently difficult. The line of fracture is so close to the knee-joint and the joint so soon becomes distended with bloody or serous effusion, or both, that the examination of the parts is often difficult. There will be localized pain and tenderness and marked tenderness along the line of fracture. There may or may not be abnormal mobility and crepitation. The deformity is usually hidden by the swelling. In these cases the X-rays are very valuable in diagnosis. I have recently had a case under my care, in which the diagnosis of fracture was not made until an X-ray picture was made.

Gunshot Fractures of the Upper End of the Tibia

When made by soft-lead rifle bullets and soft-nosed bullets, gunshot fractures of the upper end of the tibia are usually attended by much comminution and

involvement of the knee-joint, frequently necessitating resection or amputation of the limb. When made by small-caliber high-power rifle bullets the injury is usually less complicated, and may be a mere perforation without notable comminution, this being the only part of the tibia in which such relatively simple injuries are produced. Both in the shaft and the lower extremity of the bone extensive comminution with fissures running up and down the shaft, often invading the ankle or the knee, is the rule.

Separation of the Upper Epiphysis of the Tibia

According to the statistics of Poland, separation of the upper epiphysis of the tibia is the least frequent site of this type of injury among all the long bones. The upper epiphysis of the tibia appears during the first year and unites to the shaft at from the twentieth to the twenty-second year. The epiphyseal line runs close to the superior tibio-fibular joint. The injury is a rare one, less than thirty cases having been reported. In the recorded cases violent abduction or adduction of the leg has been the usual cause. The line of fracture usually includes the tubercle of the tibia in the upper fragment. The injury may be complicated by fracture of the shaft. The diagnosis of the condition is to be made from the history of the injury, from the localized pain, tenderness, and swelling, and in some cases by the ability to move the shaft upon the epiphysis laterally or the epiphysis upon the shaft. In making such motions a soft crepitation may sometimes be appreciated. In cases of doubt the X-rays might aid in the diagnosis, but unless displacement were present they would not be of value. The displacement, if present, is usually not marked and may be to either side or anteriorly. The injury is a serious one and may be accompanied by injury to the popliteal vessels.

Separation of the Tubercle of the Tibia

During recent years a number of cases of separation of the tubercle of the tibia have been demonstrated by means of the X-rays. Attention was called to this injury by Osgood.[1] The injury has usually been observed in young athletic men, sometimes as the result of violent contraction of the quadriceps extensor, as in jumping, in other cases due to direct violence from a blow over the tubercle. A tongue-shaped portion of the upper epiphysis of the tibia constitutes the smaller fragment, and it is believed in some instances that in the young the injury is complicated by a partial laceration of the epiphyseal cartilage. The symptoms produced are, according to Osgood, acute pain in the knee referred to a point below the patella. There is marked localized tenderness, but only moderate diminution of function. In many instances the diagnosis of fracture is not made and the patients continue to suffer from some

[1] Robert Osgood, "Lesions of the Tibial Tubercle," *Boston Medical and Surgical Journal*, January 29, 1903.

limitation function in the limb, accompanied by pain, when strong muscular efforts involving extreme extension or flexion of the limb are made. Immediately after the injury, upon palpation, there may be felt a prominence of the tubercle of the tibia, greater than upon the sound side. Such a prominence may be visible and may be pressed back upon the shaft with the production of pain and tenderness and even in some cases with crepitation. Dr. Stimson is of the opinion that in some of the reported cases of this injury, where the diagnosis has been made by means of the X-rays, that the interpretation of the plates has been an incorrect one. He states: [1]

It seems to me that skiagraphic appearances—the existence of a clear line between the tubercle and the shaft—have led of late to the diagnosis of fracture in some of the common cases of slight injury which do not deserve to be thus classed. Thus Schlatter, who claims seven cases in less than three years, includes those in which there was no sudden onset, no disability, no symptom except tenderness on pressure, cases, it seems to me, of slight ruptures of the periosteum or conjugal cartilage or even of exaggerated nutritive activity. I have seen a lump slowly form at the sight of the tubercle in such cases. (See also Winslow, *Annals of Surgery*, February, 1905.)

Fractures of the Shaft of the Tibia

Fractures of the shaft of the tibia may occur from direct or indirect violence. In the former group the fracture may occur at any portion of the bone and from its superficial situation throughout its length, such fractures are frequently compound. The direction of the line of fracture and the presence or absence of comminution, or of associated injuries, will vary with the character of the object causing the fracture and with the degree of violence.

In fractures by indirect violence, the tibia is rather rarely fractured alone, since, if the violence continues to act, the much weaker fibula is readily broken. When both bones are fractured, the fracture of the fibula is usually at a higher point than that of the tibia. Fractures of the shaft of the tibia by indirect violence occur most often in the lower part of the bone and frequently at the junction of its lower with its middle third. The line of fracture may be in any direction, but most often it is oblique. A peculiar and very common fracture in this part of the bone is the so-called V-shaped fracture, in which the lower end of the upper fragment ends in a sharp point anteriorly and to the inner side, while a similar point exists posteriorly upon the upper end of the lower fragment. In addition there is frequently a spiral fracture running downward into the ankle-joint, sometimes with separation of a portion of the bone from the posterior part of the lower end of the tibia. Owing to the continuance of the violence, or, subsequently, to incautious handling of the patient or to muscular contraction, the sharp point of bone constituting the lower end of the upper fragment not infrequently penetrates the skin, thus rendering

[1] L. A. Stimson, *loc. cit.*, p. 382, 1907.

the fracture compound; or, in other cases, such penetration will occur from pressure, owing to the difficulty of maintaining reduction in these cases and persistence of angular displacement.

Signs and Symptoms.—The signs and symptoms of fracture of the shaft of the tibia are those characteristic of fracture of the shafts of the long bones. There is usually complete inability to use the limb, although such is not always the case. I recall the history of a man whom I knew and who, while intoxicated, fell and sustained a V-shaped fracture of the tibia, such as just described. With this injury he walked up four flights of stairs. There are localized pain and tenderness and deformity, the latter visible as a rule upon inspection. The deformity may be in any direction, but the most common type is that of an anterior angular deformity with more or less marked projection of the upper end of the lower fragment beneath the skin. Crepitation is usually easily elicited upon gentle motions of the limb laterally, and at the same time abnormal mobility will be appreciated.

The change in the outline of the bone can, as stated, be usually discovered by simple inspection and by palpation; the finger as it passes along the subcutaneous sharp border of the shin readily appreciates the irregularity of contour at the point of fracture. The other signs—ecchymosis, swelling, etc.—are present or speedily develop. In general, the X-rays are not necessary for diagnosis of fractures of the shaft of the tibia, but, as already stated, may be very useful after reduction has been made, and the limb put up in a dressing, to discover whether the reduction has been satisfactorily maintained. When both bones are fractured, the diagnosis is even more simple. The abnormal mobility is very marked indeed, and may be appreciated upon gentle manipulations, either motions in a direction at right angles to the length of the limb or rotation. Angular deformity is also marked. It is unnecessary to determine the exact point of fracture in the fibula. All the manipulations of the limb are extremely painful and the general fact that the fibula is fractured is usually sufficiently plain.

The tendency toward displacement in the fibula is far less than is the case with the tibia. The point of fracture of the fibula may, however, usually be detected with sufficient accuracy by pressure along the shaft of the bone, when the point of fracture is reached the patient will complain of increased pain. In fractures of both bones, the determination of overriding and consequent shortening may be made by measurement from the line of the knee-joint, at the upper border of the internal tuberosity of the tibia, to the lower border of the internal malleolus; and this measurement may be compared with that made upon the sound side. In cases of doubt as to the presence of fracture, a highly important sign here, as elsewhere, is the presence of extreme local tenderness. Crowding the foot upward in the direction of the long axis of the limb also causes pain. It is very difficult in these fractures to maintain an accurate reduction, and consequently, if the surgeon's efforts in this direction fail, the period of repair will often be greatly prolonged. In fractures of the

tibia alone, where reduction is good, firm union may be expected in six or seven weeks. Where both bones are broken, it often requires a somewhat longer time, and if reduction is imperfect several months may pass before firm union is obtained.

The surgeon should be constantly on the watch for recurrences of the displacement during the days following the injury, and if a good position cannot be retained, the fracture may sometimes be converted into an open one with advantage. It will often be sufficient to cut off the sharp projecting lower end of the upper fragment. In other cases the bones may be brought into good position after incision by means of bone hooks and other devices, and then held by dressings. Personally, I have not found great advantage in these cases from drilling and suture of the tibia, even though I have sometimes in addition divided the tendo Achillis. The tendency toward displacement by the pull of the powerful muscles of the calf is sometimes very great.

FIG. 220.—FRACTURE OF THE LOWER THIRD OF THE TIBIA. The original injury was an oblique fracture of the tibia in which repeated efforts by suture, wiring, and nailing failed to keep the fragments in apposition. The ends of the tibia were sawn at right angles to the line of fracture, and a piece was resected from the fibula. The X-ray picture shows the result two years after the operation. There was an inch and a half shortening of which the patient was unconscious. (Author's collection.)

In one instance, after having made several ineffectual efforts to maintain the tibia in good position by one or other of the popular forms of external dressing, I cut down upon the fracture and first sutured the fragments of the tibia, after which the displacement recurred. At the end of a week I opened the wound again and tried to keep the fragments in place by means of a large steel nail. This also failed; when I sawed off the ends of the tibia square, thereby sacrificing about an inch and a half in the length of the bone and resected the fibula at a somewhat different level, removing a length of the shaft corresponding to the loss of substance

FIG. 221.—OBLIQUE FRACTURE OF THE TIBIA AND FIBULA WITH SOME LATERAL DISPLACEMENT, AS WELL AS OVERRIDING. There is an abundant formation of osteophytes and union between the tibia and fibula. Anterior view. These pictures of the fractures of the bones of the leg were kindly furnished to me by Dr. Adrian V. S. Lambert. (Anatomical Department of the College of Physicians and Surgeons, Columbia University.)

FIG. 222.—POSTERIOR VIEW OF FIG. 221.

in the tibia. The bones were not sutured. A very good result was obtained with aseptic healing. The bones united and (Fig. 220) in the text, shows the result two and a half years after the operation. The patient had a straight and strong limb without other deformity than the shortening, of which he was unconscious.

If these fractures are compound and become infected, union will be still longer delayed and in many there will be a more or less extensive necrosis of the tibia. Such necrosis will be, as a rule, superficial and will not absolutely prevent final union, though these patients are apt to suffer from marked pain and disability for a long period, and not rarely the wound may break down

a number of times with the formation of a small abscess surrounding a small bit of dead bone. In the very badly infected cases, the patients may die of septicemia, or amputation of the limb may be required to save life.

Fractures of the Lower Ends of the Tibia and Fibula

Fractures of the lower ends of the tibia and fibula are frequent injuries. They present a great variety of conditions, some of which, notably those caused

Fig. 223.—External View of Fig. 221.

Fig. 224.—Internal View of Fig. 221.

by great degrees of violence, such as falls from a height upon the feet, runover accidents and other similar grave injuries, are quite atypical. Others constitute several groups of a more or less typical character. Stimson [1] groups

[1] L. A. Stimson, *loc. cit.*, pp. 387–399, 1907.

these several types of fracture as follows: (1) Comminuted fracture of the lower end of the tibia with fracture of the fibula. (2) Supramalleolar fracture. (3) Separation of the epiphysis of the tibia. (4) Fractures by eversion and abduction of the foot, Pott's fracture. (5) Fractures of the malleoli by inversion of the foot. (6) Fracture of the posterior portion of the articular surface of the tibia. (7) Fracture of the anterior portion of the articular surface of the tibia.

Comminuted Fracture of the Lower End of the Tibia with Fracture of the Fibula.—These fractures may occur as the result of direct violence or from falls from a height upon the feet. The lines of fracture run in various directions, one or more lines of fracture usually running into the ankle-joint. The lower end of the tibia is frequently extensively comminuted.

An illustration of the complexity of the lesion in some of these cases is that of a young girl, aged thirteen, who came under my care a few months ago. She fell a distance of three stories from a fire escape, struck a clothesline on her way to the ground, which somewhat broke the force of the fall, and landed upon her feet. She sustained a number of contusions, scalp wounds and other superficial injuries, and a fracture of both bones of the right leg near the ankle-joint. She was treated in a hospital, and came under my care some three weeks after the accident.

The foot was in a position of moderate plantar flexion. The ankle-joint was almost completely stiff. The foot was moderately everted and could not be inverted passively beyond a sagittal vertical plane passing through the middle line of the limb. The entire foot was *displaced forward* at the ankle-joint. The external malleolus accompanied the foot, there having been a fracture of the fibula some three inches above the lower extremity of the bone. Efforts at reduction under ether were quite unsuccessful, the fragments being already partly consolidated. X-ray pictures taken of the leg showed the following lesions: There was a fracture of the fibula about three inches above the tip of the malleolus with a forward angular displacement. The internal malleolus was fractured at its base and was displaced forward. There was a fracture of the lower end of the tibia; the line of fracture began to the inner side at the base of the malleolus and extended very obliquely upward and outward, a distance of about four inches. There was marked angular displacement forward of this fragment, which included a large part of the articular surface of the tibia. The astragalus had accompanied the lower end of this fragment in its forward displacement which amounted to fully an inch. This long fragment of the tibia appeared to be impacted in or quite firmly united to the upper portion of the shaft.

An open operation was done and an effort made to bring the fragments as far as possible into their former relations. Considerable improvement in the position of the foot was obtained, but it is highly probable that the relations of the articular surfaces of the fibula, tibia, and astragalus are so changed that a stiff ankle will result.

In all these cases it should be borne in mind that if the condition is so unfavorable from irreducible displacements of the articular ends of the bones and comminution, that ankylosis will probably result; the foot should be put up straight, in a position of dorsal flexion at right angles to the leg, and neither abducted nor adducted. The diagnosis of these complicated fractures can be made by careful manipulations under a general anesthetic with sufficient accuracy to enable the surgeon to make out the situation and direction of the main lines of fracture, but a much more accurate knowledge of the exact condition of affairs may be obtained by one or more pairs of good stereoscopic X-ray pictures.

FIG. 225.—OBLIQUE FRACTURE OF THE SHAFT OF THE TIBIA. Anterior view. The fracture has been wired. (Anatomical Department of the College of Physicians and Surgeons, Columbia University.)

FIG. 226.—EXTERNAL VIEW OF FIG. 225. Oblique fracture of the shaft of the tibia.

FIG. 227.—INTERNAL VIEW OF FIG. 225. The wire may be seen at the line of fracture.

Supramalleolar Fracture.—This is a more or less transverse fracture of the lower end of the tibia somewhere near its lower end; additional lines of fracture may or may not pass into the ankle-joint. The fibula is broken at the same level or at a higher point. Tillaux, quoted by Stimson,[1]

was able to produce this form, namely, a horizontal fracture of the tibia, an inch above its lower end and a fracture of the fibula anywhere along the shaft, with or without fracture of the external malleolus, experimentally by inversion of the foot, and says the fracture then takes place first in the fibula and only in the tibia if the force continues to act; he reports one in which dislocation of the upper end of the fibula took the place of fracture of that bone, the line of fracture of the tibia lying three finger breadths above its lower surface.

Stimson adds that he sees no reason to doubt why the fracture might not also be caused by eversion of the foot.

The diagnosis of supramalleolar fracture of the tibia is to be made by the ordinary signs of fracture present—namely, by pain and tenderness along the line of fracture, and in some cases by the recognition of a horizontal displacement and by the appreciation of mobility and crepitation. Here, as elsewhere, the X-rays will exhibit the actual lesion with great clearness.

Separation of the Epiphysis of the Tibia.—Poland places separation of the lower epiphysis of the tibia fifth in frequency in the list of these injuries. It is notably more frequent than separation of the upper epiphysis of the same bone. The injury is usually produced by a cross strain producing eversion of the foot, and the degree of violence necessary for its production has varied greatly in the recorded cases, from injuries such that in an adult a comminuted fracture of the lower end of the tibia would occur, to such slight injuries as commonly produce a mere sprain of the joint. The fracture may be complicated by a fracture of the fibula, and Stimson states [2] that in some cases the outer border of the shaft of the tibia is also broken off.

FIG. 228.—FRACTURE OF THE TIBIA AND FIBULA. The fracture of the lower end of the tibia is badly comminuted. (New York Hospital collection.)

[1] L. A. Stimson, *loc. cit.*, p. 388, 1907.

[2] *Ibid.*, p. 389, 1907.

The diagnosis is to be made by the signs of the eversion of the foot, the prominence upon the inner aspect of the ankle of the sharp lower edge of the diaphysis, and by tenderness along the line of separation and by a softer crepitation upon pushing the fragment back into place than occurs when the fracture is of bone.

Fractures by Eversion and Abduction of the Foot—Pott's Fracture

Fractures of this character are produced by a sudden turning of the ankle in eversion and abduction. In some cases the eversion is the most important part of the fracturing force, in others the abduction, and the resulting injuries may be divided into two groups according to whether one or other of these motions is the more marked. In the first group, those produced by eversion, the patient slips or makes a misstep, violently displacing the foot at the ankle-joint outward, while the weight of his body continues to be borne upon the limb. The chief strain comes upon the internal lateral ligament of the ankle-joint, which may be completely ruptured, or in other cases the tip of the internal malleolus will be fractured, in still others the malleolus will be squarely fractured at its base. If the force continues to act, the fibula is crowded outward and is fractured at, or somewhat above, the base of the external malleolus. In addition there is in many cases a rupture of the tibio-fibular ligament, thus forcing the two bones apart. In other cases the tibio-fibular ligament remains unruptured, but an oblique fracture of the outer border of the tibia occurs, separating a small fragment. In the group of cases in which *abduction of the foot predominates*, the internal lateral ligament may be torn away from the tibia, either completely or only in its anterior portion, or in other cases a portion of the anterior border of the internal malleolus is fractured. If the violence continues, the tibio-fibular ligament is ruptured and a twisting strain being brought to bear upon the fibula it is fractured obliquely at a distance several inches above its lower end. In a certain group of cases the tibia is not fractured, but the internal lateral ligament is totally ruptured with fracture of the fibula near its lower end, and in these the tibio-fibular ligament may or may not be torn. In some instances the tibio-fibular ligament does not rupture, but an oblique line of fracture passes from the articular surface of the tibia upward and outward, thus creating a long external fragment. Stimson states [1] that in this group of cases two complications may appear which were first observed by him. He says: "I have seen two cases of each. One is the rotation of the internal malleolus about an antero-posterior axis, so that its fractured surface lies parallel to and just beneath the skin, the fragment being exceptionally prominent and movable. The other is the interposition between the malleolus and the tibia of a large strip of periosteum torn from the tibia; in this condition also the malleolus is exceptionally prominent and movable."

[1] L. A. Stimson, *loc. cit.*, p. 391, 1907.

These cases were treated by Stimson by open operation, with final perfect functional result in each case. In a certain proportion of the cases, when the violence has been more than ordinarily severe, the fracture is rendered compound into the ankle-joint, by perforation of the skin upon the inner aspect of the ankle, by the lower end of the tibia. The signs and symptoms of this variety of Pott's fracture are so clear that the diagnosis can usually be made upon inspection. The entire foot is displaced outward and backward. Such displacement may be slight, or in some cases it is extreme. The lower end of the tibia forms a marked prominence upon the inner aspect of the joint. If the case is not seen for some hours or a day, great swelling will be present, with distention of the ankle-joint by blood, but this rarely, if ever, is so extensive as to hide the perfectly characteristic deformity. The lateral mobility of the foot is one of the characteristic signs of Pott's fracture. It may readily be appreciated by grasping the leg above the ankle-joint firmly with one hand, while with the fingers and thumb of the other the foot is firmly grasped from beneath, opposite to the ankle-joint. Lateral motions, both outward and inward, can then readily be made of the foot and the abnormal mobility appreciated. Care should be used to grasp the astragalus, not the os calcis, since lateral mobility of the former, not of the latter, is significant. The finger and thumb should be placed just below either malleolus. In making these movements, it is sometimes possible to get a bony click as the astragalus strikes against the tibia. The abnormal mobility of the foot in an antero-posterior plane may be appreciated in a similar manner, or, as the patient lies, the leg may be supported by the fingers and the foot lifted forward and again allowed to drop into its abnormal backward position. The other ordinary signs of fracture are present. If the foot is crowded inward and the malleolus is fractured, the fragment may readily be felt beneath the skin, and may sometimes be pushed up against the lower end of the tibia with the production of crepitus. As stated, very marked swelling of the foot and ankle quickly appears and is followed by ecchymosis, most marked over the inner aspect of the limb, but also present, as a rule, upon the outer side. The points of extreme local tenderness observed are three—namely, over the tip of the inner malleolus, over the external malleolus or lower part of the fibula at the point of fracture, and in the space between the separated lower extremities of the tibia and fibula.

The function of the limb is more or less completely abolished, yet in some cases the patients are able to walk a little by bearing the weight carefully in a vertical line upon the injured foot, where marked displacement exists; however, total inability to walk is the rule.

The prognosis of Pott's fracture depends to a very great degree upon the efficiency—that is to say, upon the completeness—with which reduction is effected and maintained. If through the fault of the surgeon or the patient such reduction and maintenance fails, the after results are very unfavorable, the patient being left with a weakened and crippled ankle-joint and foot.

The deformity remaining is that known as pes valgus, and since the weight of the body falls improperly upon the astragalus, the weakened internal lateral ligament is kept upon the stretch and the ankle-joint remains permanently weak and painful. The reduction, best effected under general anesthesia, is made by crowding the heel forcibly forward and inward and maintaining the foot in a position of marked inversion and dorsal flexion throughout the treatment. In the cases which become compound a good result may usually be obtained unless the wound become infected, when free drainage of the joint should be made on either side and the foot kept at a right angle to the leg in the hope of obtaining ankylosis in this position. In debilitated and diabetic subjects amputation is sometimes necessary.

Fracture of the Lower End of the Tibia and Fibula by Inversion of the Foot

These injuries occur from a simple twist of the ankle inward, while the weight of the body is borne upon the inverted foot, or may occur from more severe degrees of violence, such as falls from a height upon the foot when the weight of the body comes upon the ankle, while the foot is supinated. Several types of fracture may occur, according to the degree of violence which produces the injury. In the cases following slight degrees of violence, such as a mere twist of the foot while walking or standing, traction upon the external malleolus through the external lateral ligament produces a fracture of the malleolus, usually at or near its base, or in young persons through the epiphyseal cartilage. In a second group of cases the same injury occurs, but to it there is added a fracture of the tip of the internal malleolus by the impact of the astragalus against it. In a third group of cases, usually due to extreme degrees of violence, the fibula is fractured in the same place, while a considerable fragment of the tibia is created, including the entire internal malleolus, the line of fracture running up the shaft obliquely inward a variable distance. This group may be accompanied by rupture of the tibio-fibular ligament. The gravity of these conditions varies considerably. In the first form there is no tendency to displacement nor any distortion of the ankle-joint. The patients get well rapidly under protection and immobilization of the ankle. In the second group the injury is somewhat more serious and convalescence is more prolonged, but no permanent disability or deformity is likely to follow if the case be properly treated. In the third group the injury is a very serious one. The fragment of the tibia may be displaced upward and inward a variable distance, and the displacement, though in many cases slight, in others may be considerable, so that unless the fragment is brought down with great accuracy into its former position a permanent change occurs in the shape of the articular surface of the tibia, such that it may not properly fit the astragalus, and a greater or less permanent disability may result. In the first group of cases, in which the external malleolus is fractured at its base, there will be, fol-

lowing a history of a twist inward of the ankle or a fall of moderate severity upon the supinated foot, pain referred to the region of the ankle, which may be slight or severe; the patients are still able to walk with a limp. The most marked diagnostic signs are: (1) A line of extreme tenderness on palpation at the seat of the fracture in the fibula. (2) Mobility of the fragment, which is elicited in the following manner: The surgeon places the tip of his thumb upon the point of the external malleolus, and the limb being supported either across his knee or upon a table or bed, grasps the limb from in front just above the ankle-joint with the other hand to steady it. Pressure with the thumb over the malleolus may at once cause it to rock against the tibia in such a manner that the examining fingers above readily detect the mobility of the upper end of the fragment, or pressure upon the base of the malleolus at the point of fracture may cause its tip to rock back and forth beneath the examining thumb below. If the leg be grasped above the seat of fracture and strong pressure be made upon the fibula, it will frequently cause pain where the bone is broken. In the second group of cases there will in addition be a point of extreme tenderness and pain over the tip of the inner malleolus, and the presence of a loose fragment in this situation, sometimes with crepitation, may be detected. The signs of swelling and inflammation of the ankle-joint will be more marked. In the third group of cases, in addition to the signs of fracture of the fibula there will be tenderness along the line of fracture of the tibia extending a variable distance up the shaft, according to the size of the fragment, and if displacement exists an irregularity in the contour of the bone can usually be appreciated. It may be possible, moreover, to move the fragment of the tibia up and down upon the shaft and to elicit crepitation. Other signs of fracture and marked disability are present in these cases. The actual size and shape of the fragments are readily shown in X-ray pictures.

Fracture of the Posterior Portion of the Articular Surface of the Tibia.—This injury may occur as a part of the lesion of a severe Pott's fracture, such as may be produced by a fall from a height, and in these cases there may be more or less extensive comminution of the lower end of the tibia. The existence of the fracture, when it occurs alone or associated with a fracture of the fibula, may best be recognized with certainty by means of X-ray pictures.

Fracture of the Anterior Portion of the Articular Surface of the Tibia.—This is a rare injury produced by the impact of the astragalus against the anterior border of the articular surface of the tibia. It could probably be recognized by ordinary methods of examination and certainly by means of the X-rays.

Fractures of the Fibula

Fractures of the fibula may occur at the upper end, or, as already described, at the lower end, and, furthermore, the shaft may be broken. Fractures at the upper end may occur from direct violence, as from blows and falls upon

the upper part of the bone, or rarely by muscular action due to violent contraction of the biceps muscle. A third group of cases is constituted by fractures caused by adduction of the leg and traction through the external lateral ligament of the knee-joint. An associated lesion in a certain proportion of cases is injury to the musculo-cutaneous branch of the external popliteal nerve. The nerve in its exposed position on the neck of the fibula is sometimes injured by the same violence which produces the fracture, or may be pressed upon later by callus or displaced bone. For symptoms of disturbance of this nerve, see Injuries of the Nerves of the Lower Extremity. In certain cases there will be little or no displacement; in others, the upper fragment is displaced upward a variable distance. The recognition of the fracture is easy upon palpation, abnormal mobility of the upper fragment being the most marked sign, together with localized pain and tenderness.

FIG. 229.—OLD UNITED FRACTURE OF THE UPPER END OF THE FIBULA DUE TO DIRECT VIOLENCE. Union with little if any displacement. No symptoms of nerve irritation. (Author's collection.)

Fractures of the shaft of the fibula occur from blows upon or falls against the bone. Owing to the support afforded by the tibia, and the fact that the bone is everywhere surrounded by muscles, there is usually very little displacement. The other signs of fracture are, however, present. Localized pain and marked tenderness when the point of fracture is pressed upon, together with mobility of the fragments, can usually be appreciated. A very few cases have been reported of separation of the lower epiphysis of the fibula.

Dislocations of the Fibula

The fibula may be dislocated either at its upper or at its lower end. In addition to dislocations by external violence, the fibula may be dislocated by muscular action, or gradually by inequality of growth between the tibia and fibula. The dislocations of the upper end may be outward and forward, backward or upward. The dislocation may be associated with fracture of the tibia, or of the fibula, or of both bones. The forward dislocations may occur from external violence or from muscular action. The diagnosis is entirely simple, the displaced head of the bone is readily felt in its abnormal position, and the tendon of the biceps is observed prominent beneath the skin. The backward dislocations are extremely rare. They are believed to be due either to muscular contraction, or in other cases to traction by the external lateral ligament of the knee-joint in violent wrenches of the leg. In this form also the diagnosis is entirely simple upon inspection and palpation. Upward dislocations are exceedingly rare, according to Stimson, only three cases having been reported. The dislocation affects both ends of the bone. There is marked disability of the ankle and the displaced bone is readily palpated in its new position.

Fig. 230.—Gunshot Fracture of the Lower Ends of the Tibia and Fibula, showing Production of New Bone and Small Fragments of Bullet. The wound was produced by a brass-jacketed Remington bullet. A sinus remained in the soft parts from which some pieces of bullet were extracted. (Author's collection.)

Dislocation of the lower end, except as a complication of Pott's fracture, is exceedingly rare. It is produced by eversion of the foot and by rupture of the tibio-fibular ligament. Stimson [1] states that there are but two recorded cases. In the case of Tillaux's, quoted by Stimson,

[1] L. A. Stimson, *loc. cit.*, p. 812, 1907.

the patient in stepping from an omnibus caught his foot and fell forward. The foot was everted, there was a large ecchymosis on the inner side of the leg and foot and another on the outer side; the ankle was swollen and tender, especially on the inner side; no fracture could be found. The lower end of the fibula was freely movable forward and backward with cartilaginous crepitus and could be drawn outward so far that the end of the finger could be inserted between it and the astragalus. The patient made a good recovery.

Spontaneous or Pathological Dislocations.—Dislocations of the upper end of the fibula have been recorded as the result of destructive inflammations of the tibio-fibular joint and from overgrowth of the tibia following osteomyelitis. It has also been observed as the result of rachitic disease of the bones.

CHAPTER XXVI

DISEASES OF THE LEG

Every variety of skin lesion, whether due to injury or disease, is observed upon the skin of the leg. It is the home of the varicose ulcer, a favorite site for chronic eczema and for tertiary syphilitic lesions. All the inflammatory processes of the skin, furuncles, small abscesses, erysipelas, lymphangitis, etc., occur upon the leg with great frequency, and while the diagnosis of these various conditions has for the most part already been elsewhere described, in the leg they possess certain peculiarities which demand attention. Phlebitis and periphlebitis, sometimes with abscess formation, are not infrequent complications of ulcers of the leg of the chronic variety. The deep-seated suppurative processes in the intermuscular planes are less common in the leg than in the forearm, and yet they nevertheless occur with considerable frequency; sometimes as an extension from suppurative processes of the foot, sometimes from infected wounds of the soft parts, as a complication of fractures of the tibia and fibula, and as a secondary process in cases of acute suppurative osteomyelitis of the tibia. The calf of the leg may be the seat of bed-sores in cases of paraplegia due to injury or disease of the spinal cord; and in a good many instances I have observed pyemic abscesses localized in the thick muscles of the calf. The reparative processes in lesions of the leg, whether in the nature of wounds or infectious lesions of any sort, are not as active as in the upper extremity, on account of the less perfect circulation produced by maintenance of the erect posture. The various ulcers, wounds, and superficial inflammatory lesions of the leg are usually not as painful as similar conditions in the forearm, and do not, as a rule, interfere with locomotion, so that individuals thus afflicted are apt to continue upon their feet. As a consequence, such conditions are prone to become chronic or to heal but slowly, and this is more particularly true of those who have varicose veins of the leg with imperfect valves.

ULCERS OF THE LEG

Three lesions are so commonly associated in the leg that they may be said to constitute together practically a pathological entity; they are *varicose veins of the leg, chronic eczema, and chronic ulceration.* They affect people during adult life and middle age, and are especially frequent among those who have varicose veins and are obliged to be all day long upon their feet, and who, in addition, are uncleanly. The varicose veins having once developed,

the appearance of a chronic eczema followed by an ulcer sooner or later occurs in a large proportion of cases. The patients rarely belong to the well-to-do class, who receive suitable treatment for the varicose veins, or who take suitable care of a slight injury of the shin. Laboring men, cooks, waiters, and stout, middle-aged females who have borne a number of children, are regularly the sufferers from this condition.

History of the Ulcer.—*In typical cases of chronic ulcer of the leg* the history is often as follows: An individual of careless and uncleanly habits afflicted with varicose veins of the leg receives some trifling injury, a wound or abrasion upon the shin, and neglects it. A slight infection follows, and the healing is delayed by a more or less acute suppuration of the raw surface. Healing finally occurs, but the scar remains weak and friable. Another slight injury

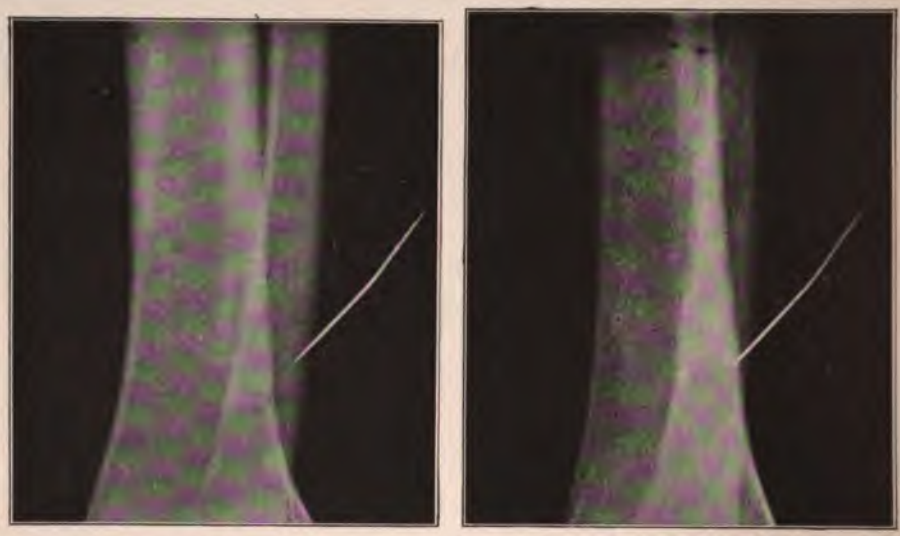

FIG. 231.—STEREOSCOPIC X-RAY PICTURES OF A NEEDLE EMBEDDED IN THE SOFT PARTS OF A MAN'S LEG. If these pictures be viewed through an ordinary refracting stereoscope, the relation of the needle to the bones can be plainly seen. (Author's collection.)

follows at the same point, and this again becomes infected and is again neglected. Healing is still further delayed, and the individual often develops a papular or a vesicular eczema as the result of the irritation of the surrounding skin produced by the infectious discharge, notably if improper and dirty dressings are applied and kept on for many days. In other cases the eczema is first developed as the result of imperfect nutrition of the skin and mechanical or other irritation. The patient scratches the itching area and produces an infected abrasion with his finger nails. In still other cases, an eczema or a small wound occurs at the site of some former injury which has left behind a mass of poorly nourished scar tissue; such may be an ordinary wound, a burn, or any other lesion which has left a scar behind. No matter how the process originates, a time arrives when the infected raw surface produced no

longer heals. The attacks of acute inflammation have been accompanied by infiltration of the surrounding skin with leucocytes and finally by the formation of cicatricial tissue. Each succeeding attack of acute inflammation is followed by the production of more connective tissue of new formation, and, as time goes on, this contracts and still further impairs the blood supply of the skin. The edges of the ulcer and the surrounding skin become hard and leathery. Under appropriate treatment it is possible for these ulcers to heal, and if properly cared for and protected a recurrence may be avoided; but since the individuals are usually ignorant, poor, dirty, and careless, they neglect themselves so that the conditions are unfavorable for permanent cure.

In another group of cases the ulcer begins at the site of rupture of a varicose vein, or in the skin overlying an area of periphlebitis affecting such a vein. Other and less common causes for the production of chronic ulcers of the leg are the scars and sinuses left after an acute or chronic osteomyelitis of the tibia, the scars of former tuberculosis of the skin secondary to tuberculosis of bone, or syphilitic scars. Be the origin of the condition what it may, the course of the disease, other things being equal, is much the same.

Favorite Sites.—The favorite sites for chronic ulcer of the leg are at the junction of its lower and middle thirds, most often over the subcutaneous surface of the tibia in front, sometimes over, or just behind, one or other of the malleoli, though any other part of the leg may be affected. The ulcers may be single or multiple.

Size and Shape.—In size and shape they vary in different cases according to the age of the ulcer and other conditions. When well developed, one may find an ulcer varying in size from a minute point up to a raw surface as large as a silver dollar, or in some cases as large as the palm of a hand, and in still others the entire limb will be encircled by a raw ulcerated surface occupying a very large area indeed. The surrounding skin is hard and leathery, immovably attached to the deeper soft parts, and even the tibia. The whole leg and ankle are frequently edematous; the skin surrounding the ulcer is blue or purplish-red, or brown, owing to a deposit of blood pigment and to chronic venous congestion.

Character.—An almost invariably accompanying lesion is a *chronic squamous eczema*. The skin is covered with scales of dry horny epithelium. Such may be small and thin, or may consist of thick crusts and masses of epithelium mixed and cemented together by dried discharge. If such crusts be removed the underlying skin is smooth, glistening, and moist. In old and chronic cases the skin not only surrounding the ulcer but also of the foot is markedly thickened, rough, and elevated into warty prominences. The edges of the ulcer are of a cartilaginous hardness, owing to the infiltration of the skin and subcutaneous tissues with dense scar tissue. The ulcer itself is of *varying depth*, according to the duration of the process and the number of attacks of necrotic infection which have preceded. In recent cases the ulcer may be only one eighth of an inch deep, or in others it may extend down to or even involve the

periosteum or the tibia itself. The *base* may be covered with flabby, pale granulations, or in cases in which the reparative process is at a standstill, the base of the ulcer will consist of a smooth, glistening, pale surface of dense fibrous tissue upon which no granulations can be detected. Such a surface may be covered with a thinner or thicker pellicle, or soft scab of partly dried semi-purulent discharge. In other instances, if at the time the ulcer be acutely infected with pyogenic germs, the discharge will be profuse and distinctly purulent. The base of the ulcer in these cases will be covered by a yellowish slough, or with infected granulations. In still other cases, following an attack of acute infection, the base of the ulcer will be black and necrotic, and will give forth a foul, putrid, stinking discharge of a thin and watery character.

Varieties.—In former days it was customary to group ulcers under various heads according to their clinical characters, though such grouping had no particular pathological significance. Though many of the terms thus used are now obsolete, I give them here for the sake of completeness. Thus, it was customary to speak of *healthy* ulcers, and by this was meant that the process of granulation and healing was going on in the ulcer and that it presented the appearances of a healthy healing sore—namely, that the granulations were red and bled readily upon mechanical irritation, that the amount of discharge was slight and watery rather than purulent, and, further, that the epithelium was growing in from the edges of the raw surface toward the center, thus covering in the granulations.

The ordinary type of chronic ulcer of the leg which showed little or no tendency toward spontaneous healing was known as *an indolent ulcer.* The edges of the ulcer were hard and poorly nourished, granulations were absent or, if present, they were pale, flabby, and anemic, or the base of the ulcer was covered with a soft purulent or sloughy crust. The discharge from such an ulcer might be distinctly purulent, watery or blood-stained, according to the character and intensity of the pyogenic or other infection. *Sloughing or gangrenous ulcers* were those in which the base of the ulcer was necrotic, or had undergone putrid decomposition, as already described. *Irritable or painful ulcers* were those showing extraordinary sensitiveness when irritated. They are superficial ulcers in which the nerve endings of the skin are exposed. *Phagedenic ulcers* was the term used to describe any form of ulceration which tended to progress more or less rapidly from the edges and in depth, due to any form of infection causing progressive necrosis of tissue, in the presence or absence of an impoverished blood supply. Other terms which have been used to characterize ulcers are *fungous or fungating ulcers.* By this was meant that poorly nourished granulations sprang from the base of the ulcer and projected above the level of the surrounding skin. Although the term has no distinct pathological significance, it has been used as a descriptive term in tuberculous ulceration, and even to describe the exuberant masses of epitheliomatous tissue which project above the surface of an ulcerated epithelioma. The term *rodent ulcer* was used as descriptive of the slowly progressive forms

of epithelioma described in Vol. I and elsewhere under Tumors. The terms *indurated ulcer, fissured ulcer, and fistulous ulcer* describe themselves. Other terms are trophic ulcer, described under Injuries of Nerves; Marjolin's ulcer, used to designate the malignant degeneration (epitheliomatous degeneration) which sometimes occurs in the base of a chronic ulcer wherever situated.

Acute and Chronic.—The terms *acute* and *chronic ulceration* serve to distinguish clinically between rapidly progressive forms of tissue necrosis due to various kinds of infection, or to want of blood supply, or, on the other hand, the term chronic is used as descriptive of any of the forms of progressive tissue destruction, syphilitic, tuberculous or other, in which the course of the process is slow and chronic. A peculiar form of ulceration, elsewhere described, is that which follows prolonged exposure of the skin to the X-rays. (See the X-rays in Surgical Diagnosis, Vol. I; also Diseases of the Hand, Vol. III.)

FIG. 232.—GREAT HYPERTROPHY OF THE SOFT PARTS OF THE LEG AND FOOT FOLLOWING VARICOSE VEINS OF THE LEG WITH CHRONIC ECZEMA, ULCERATION AND REPEATED ATTACKS OF CELLULITIS OF THE LEG.

As already indicated, chronic ulcers of the leg may become so extensive that they girdle the limb. In these cases not only the venous but also the lymphatic circulation may be seriously interfered with, so that the leg below the ulcer and the foot may undergo a sort of elephantiasis. The parts below the ulcer undergo a marked increase in size; the skin becomes enormously hypertrophied and elevated into warty, nodular, rough, uneven masses. The subcutaneous tissues are infiltrated with inflammatory tissue of new formation. In the worst cases a similar infiltration occurs into the muscles, into the tendon sheaths, and even involves the bone. The muscles undergo atrophy, the tendons are locked in their sheaths, bone may be eroded or irritated with the pro-

duction of osteophytes. The ankle-joint and the joints of the foot become immobile, and the function of the limb is greatly impaired.

It happens occasionally that a chronic ulcer of the leg from whatever cause undergoes an EPITHELIOMATOUS DEGENERATION. This change may be suspected when hard, firm granulations sprout up from the base of the ulcerated area above the level of the surrounding skin, which bleed readily; and where the condition cannot be improved by rest in bed with elevation of the limb, by cleanliness, support of the circulation, and other measures of a curative character in ordinary forms of ulceration. The *diagnosis of epithelioma* is to be confirmed by removing a fairly liberal piece of the granulating surface and including also a portion of the border of the ulcer. The excision should go rather deeply into the underlying structures, for even by microscopic examination, in the early stages of these cases the diagnosis may be a little doubtful, unless the piece excised is of the character described. I have happened to treat a considerable number of these cases. In some the epitheliomatous degeneration occurred on an ordinary chronic ulcer of the leg associated with varicose veins. In one case the epithelioma developed in the base of an ulcer which had existed for many years in the scar of a very ancient, deep burn of the leg. In some of these cases infection of the lymph nodes of the groin is long delayed; in others it occurs at rather an early period. In the case mentioned where the epithelioma developed in the scar of an ancient burn, a change in the character of the ulcer, suggesting malignant degeneration, had occurred only two or three months before I saw the case. The diagnosis was readily made upon examining a portion of the hard granulation tissue under the microscope. The patient was a man aged fifty-two years, in good general health and of powerful physique. I amputated in the middle of the thigh. At that time there were no evidences of an enlargement in the inguinal lymph nodes. Six months later the lymph nodes were enlarged and hard, and I extirpated all the glands on that side. Local and regional recurrences took place after a few months. I treated the recurrences with the X-rays, the condition being entirely inoperable. Though the tumors grew smaller for a time, no permanent benefit followed, and the patient died of general carcinosis. In very recent cases and in those in which the carcinomatous area is small and superficial, an extirpation of the ulcer, including a considerable area of surrounding healthy tissues, followed by skin grafting, may be sufficient to affect a cure, though in many instances amputation will be necessary. The best treatment in the individual case must be decided according to the conditions present.

Complications of Chronic Ulcer.—All the forms of chronic ulcer of the leg may be complicated by attacks of ERYSIPELAS of greater or less severity, sometimes the ordinary cutaneous variety, sometimes of a *phlegmonous and necrotic character*, attended by grave constitutional disturbances and by widespread necrosis of the subcutaneous tissues. During the days when I was interne in Bellevue Hospital I saw a good many of these cases among the debilitated subjects who were admitted to the erysipelas pavilion in that institution. A

man would be admitted with the history that he had suffered from a chronic ulcer of the leg, associated with varicose veins, for months or years. He would usually be very ill indeed, with a high temperature, a rapid pulse, and marked prostration. In some of the cases there would be vomiting, diarrhea, and cerebral symptoms. The affected limb would be greatly swollen; sometimes of a mahogany-red color from the ankle to the knee. The surface of the ulcer would be sloughing or necrotic. There were, as a rule, no localized subcutaneous abscesses developed; but a widespread necrotic inflammation of the subcutaneous tissues with thrombosis of the veins. Numerous long incisions would be made and permit the escape of thin, sometimes stinking, brownish fluid, and later there would follow, if the patient survived, a process, partly suppurative and partly necrotic, with the escape of numerous sloughs of subcutaneous origin. Healing and convalescence was usually long delayed.

LYMPHANGITIS, due to an acute infection, is a complication often observed in the course of chronic ulcer of the leg. The signs and symptoms are characteristic. The ulcer will exhibit the signs and symptoms of acute infection. Its edges will become more reddened and swollen, the quantity of discharge will increase and become distinctly purulent in character; the granulations, if such are present, will fade away and the base of the ulcer will become sloughy. Subjectively, the ulcer will become painful. The red streaks running upward toward the popliteal space, or in other instances upon the surface of the thigh toward the groin, will readily be seen on inspection, though this sign is usually not as marked in the leg and thigh as it is in the forearm and arm. The lymph nodes of the groin will become swollen and tender.

PYEMIA.—One of the complications of chronic ulcer of the leg is septic thrombophlebitis. The symptoms produced do not differ from those which occur from pyemia in other situations. (See Pyemia, Vol. I.)

PHLEBITIS AND PERIPHLEBITIS are frequent complications of chronic ulcer of the leg. They will be mentioned when discussing varicose veins of the leg.

The various forms of TUBERCULOSIS OF THE SKIN are observed upon the leg. They may originate from infection of the skin itself, or through the blood, or may be secondary to tuberculosis of the bones of the leg. In the last group of cases the diagnosis is usually very easy from the history of a cold abscess communicating with tuberculous bone, and the typical appearances of a tuberculous sinus. In the other forms the diagnosis must be made from the data given in Vol. I under Tuberculosis of the Skin.

SYPHILITIC ULCERATION OF THE LEG.—Syphilitic ulceration of the leg may occur as the result of the breaking down of gummata of the soft parts, or as a secondary process following gummatous inflammation of the periosteum or bone. The latter are very frequent and will be mentioned under syphilitic inflammation of the bones of the leg. Not only *tertiary* but also *secondary* syphilitic eruptions may occur upon the skin of the leg. Their diagnosis depends upon a history of syphilis, upon the peculiar characters of syphilitic skin lesions as described in Vol. I, upon the detecting of the spirochetæ in the

scrapings from raw surfaces in suitable cases, and sometimes by the Wassermann reaction and from the efficiency of antisyphilitic treatment. The characters of syphilitic ulcerations following gummata are quite typical. The ulcers may be situated anywhere upon the leg. They are usually circular in outline, with a punched-out border, and a base composed of typical gummy material suggesting raw bacon in appearance. They may be symmetrical upon the two limbs. Such gummatous ulcerations may take on a serpiginous character, healing in one place while the ulceration advances in a new direction. (See also the chapter on Syphilis in Vol. I.) Here, as elsewhere, in cases of doubt the administration of large doses of iodid of potassium and local treatment of the ulcer with calomel will often establish the diagnosis, since syphilitic processes are favorably affected by antisyphilitic treatment. It is to be borne in mind, however, that a syphilitic ulceration may become infected secondarily with pyogenic microbes, and may exhibit all the characters of an ordinary chronic ulcer, or in other cases the syphilitic characters, though still present, may be more or less completely obscured by the secondary pyogenic infection. The scars left after gummatous ulcers have healed are circular, often depressed; if recent, copper-colored; later, white. They may be adherent to underlying bone.

Treatment of Chronic Ulcers.—The cardinal principles of treatment in chronic ulcers of the leg are, rest in the recumbent posture with elevation of the limb, cleanliness, careful antiseptic treatment of the ulcer, together with non-irritating applications to the associated eczema, with support of the circulation by the application of strapping and of bandages, taking care to afford free exit for the discharge. The applications to the ulcer itself should consist of *antiseptic solutions*, or of *dry powders, rather than of ointments.*

VARICOSE VEINS OF THE LEG

Varicose enlargement of the veins of the leg is a very common disease. Mode of life, racial peculiarities and heredity appear to be predisposing causes in a certain proportion of cases. The development of the disease is most common between the twentieth and the fortieth year, although it is observed in young persons, notably among boys and girls who grow very rapidly and become very tall. Occasionally the condition develops only late in life. As active or exciting causes may be mentioned, any interference with the return of the blood of the lower extremity to the veins of the abdomen and thence to the heart. Among such causes may be mentioned any of the abdominal tumors causing pressure upon the veins of the belly, whether malignant or benign. Of special frequency, also, is the influence of pregnancy. In pregnancy, however, it is to be observed that it is not alone the mechanical pressure of the pregnant uterus upon the veins of the abdomen which produces a varicose condition of the veins of the leg since dilatation of these veins is often observed during the early months of pregnancy, before the uterus has enlarged sufficiently to in-

terfere mechanically with the return of the venous blood from the limbs. Occupations which necessitate standing much upon the feet are often an exciting cause of varicose veins. The essential lesion is a dilatation of the affected veins with thinning and partial atrophy of their walls and a consequent failure of the valves properly to support the column of blood. The valves, in other words, become incompetent.

All the subcutaneous veins of the leg and thigh may become varicose, although the most frequent seat of the lesion is in the superficial subcutaneous veins and notably the veins which drain into the internal saphenous, or in some cases the saphenous vein itself. The lesion may affect also the deep veins of the extremity. In some of the cases the large, named, veins are solely or chiefly involved; in others the smaller veins of the skin are also varicose, while in still others the large veins are scarcely affected, while the small cutaneous and subcutaneous venous branches are extensively enlarged, tortuous and dilated over a large part of the limb. Thus we see in certain cases a mass of large tortuous, dilated veins looking like cords or worms, some of them as thick as a lead pencil, or as a man's finger, beginning upon the lower and inner aspect of the limb near the ankle and extending upward upon the calf, or upon the front of the leg, to end at the popliteal space; or, in other cases, the main trunk of the internal saphenous, together with several of its branches, will form a tortuous canal readily visible upon the thigh, to end often *in a marked sacculated dilatation*, opposite to the saphenous opening. In other cases such localized dilatations are observed at any point in the course of the enlarged veins, or perhaps more frequently such a dilatation is observed in the popliteal space. When the individual lies down, and more especially if he lies down and elevates the affected limb, the blood flows out of the large veins and the dilatations become invisible. In cases associated with chronic eczema, with induration of the skin and subcutaneous tis-

FIG. 233.—VARICOSE VEINS OF THE LEG, ULCER OF THE ANKLE. Cure by excision. (Case of Dr. Charles McBurney, Roosevelt Hospital.)

sues, the veins which stand out as prominent masses when the individual is erect disappear in the recumbent posture and remain only as slightly depressed grooves running through the hardened subcutaneous tissues.

A test which was devised by Trendelenburg for determining whether the valves of the dilated veins were or were not competent, is sometimes useful and is performed as follows: The patient is placed upon his back and the affected limb is elevated. The dilated veins promptly empty themselves into the general circulation. Pressure is then made upon the saphenous vein just below the saphenous opening. The patient is then permitted to get up. The dilated veins slowly fill with blood and again become visible. The finger is then removed from the saphenous vein. *If the valves of the veins are incompetent* the blood will rush suddenly downward by gravity and fill the dilated vessels throughout the limb almost instantly, and they will again become markedly distended and prominent.

In the cases in which the smaller veins are chiefly or solely affected—and in this latter group the patients are more often women than men—one finds larger or smaller areas, sometimes as large as a man's hand, sometimes occupying nearly the whole of the leg, where the minute veins of the skin and subcutaneous tissues are dilated. The dilated vessels are readily observed as a fine blue network shimmering through the skin with here and there a small bluish nodule as large as the head of a pin, or as large as a pea or larger, representing sacculated dilatations of greater or less size. Upon palpation these areas may feel firmer than the surrounding parts on account of the production of new connective tissue, or, on the other hand, they may be of a spongy consistence. This group of cases is not in general amenable to operative treatment, unless the large venous trunks be also dilated.

In those cases in which considerable sacculated dilatations occur in the large veins, the blood current may be so feeble that stagnation and coagulation take place. In a few cases spontaneous cure by the formation of *organized thrombi* and obliteration of the vein is a possible though rare incident. Such thrombi may undergo *calcification* with the production of *phleboliths*. In these cases of thrombosis it is to be borne in mind that a certain peril exists for the individual, namely, that the coagulum may spread throughout the large venous trunks to the saphenous opening and thence to the femoral vein with the production of embolism of the pulmonary artery. Therefore, when the existence of such widespread thrombosis appears possible from the occurrence of pain, swelling of the limb and the formation of a hard cord in the course of the dilated venous trunk, the patient should be put to bed in the recumbent position with the limb elevated and should not be allowed to move about for ten days or a fortnight.

As the result of the impaired circulation in the skin and subcutaneous tissues of the leg and foot, the nutrition of the limb is more or less seriously interfered with. The leg may be habitually edematous and congested, and, as described in the previous section, the occurrence of *chronic eczema and ulceration* is exceedingly common from slight mechanical and chemical insults. In

old and neglected cases the skin and subcutaneous tissues of the foot, ankle, and leg become hard and fibrous and adherent to the deeper structures.

The subjective symptoms produced by varicose veins of the leg vary somewhat in different cases. In a general way, these patients suffer from a sense of weakness in the limb, of fullness and distention, the muscles become readily fatigued on exertion, and pain is a common symptom. The pain may be in the form of *neuralgias,* frequently referred to the *sciatic nerve* and its distribution, in addition to which there may be *sudden severe cramplike pains* in the muscles of the limb. In different cases these symptoms may be entirely absent or more or less marked. The larger the number of veins affected, and especially in those cases in which a diffuse enlargement of the minute veins occurs, the more pronounced will be the symptoms and the disability. Among the accidents which may happen in cases of varicose veins of the leg are, rupture of a vein, or the accidental wounding of a dilated vein. The hemorrhage which follows varies in amount with the size of the opening and more especially with the treatment, or want of treatment. Among ignorant individuals it often happens that a ligature is placed around the limb between the rupture and the trunk; such ligatures are not applied tightly enough to shut off the arterial circulation; as a consequence, very rapid or even dangerous bleeding may occur from the ruptured vein. I have seen numerous instances of this kind in the hospitals where the degree of anemia produced was serious. Fatal cases of bleeding from this cause have been observed. The bleeding is, of course, very easily controlled by slight pressure over the point of rupture or by the application of a pad and bandage with elevation of the limb.

When the rupture takes place subcutaneously there will be produced a more or less widespread infiltration of the subcutaneous tissues of the limb with blood. The signs and symptoms will be swelling of the extremity and the occurrence of widespread ecchymosis.

Phlebitis and Periphlebitis.—Attacks of acute inflammation of the walls of varicose veins and of the surrounding subcutaneous tissues, which may remain localized outside the vein, or be accompanied by thrombosis of the same, are frequent accidents. When the vein is superficially placed, the signs and symptoms are quite marked. The vein increases in size and becomes hard. It is surrounded by a more or less extensive area of infiltrated subcutaneous tissue, over which the skin is reddened. There is tenderness on pressure, as well as spontaneous pain along the course of the vein. Constitutional symptoms—fever, prostration, leucocytosis, etc.—will be more or less marked according to the character and extent of the infection. In some cases, under rest and suitable treatment resolution occurs with or without thrombosis of the affected vein and possible cure. In others localized abscesses may be formed, either around the vein or in the caliber of the vein itself, with perforation of its wall and the formation of a subcutaneous abscess. The signs and symptoms of such abscesses in the course of the vein are the usual ones of abscess in other situations and need no special description. In these suppurative cases the dangers of

pyemia and septic embolism are fairly marked, though in my experience they are rare accidents.

Diagnosis of Varicose Veins.—The diagnosis of varicose veins of the leg is usually entirely simple. The veins are visible upon inspection, when the patient stands erect. There is edema of the ankle and over the lower third of the tibia.

In some cases it may happen that the *large deep veins* of the extremity are notably varicose, while the *superficial veins are not affected.* In these cases, however, it will usually be found that groups of the smaller subcutaneous veins, notably in the region of the ankle, are varicose, and if, under such conditions the individual complains of pain in the limb, of a sense of weakness and of cramplike pains in the muscles of the thigh at night, and of pain in the course of the sciatic nerve, a varicose condition of the deeper veins is a highly probable diagnosis.

ELEPHANTIASIS OF THE LEG

Obstruction of the lymph channels of the lower extremity from any cause may give rise to the condition known as elephantiasis. In the largest proportion of the cases the disease is due to infection with filariasis, as described in Vol. II, under Elephantiasis of the Scrotum and Penis. A certain proportion of the cases are due to obstruction of the lymph channels from other causes such as surgical operations which destroy a large number of lymph vessels, thrombi, pressure of tumors, chronic inflammatory conditions, occasionally intense and often repeated venous congestion of the limb from any cause, and in rare instances it is observed as a congenital condition. Some of the cases seen in the United States are due to filariasis, others are due to some of the causes just mentioned. In others the condition seems to be rather one resembling diffuse tumor formation than anything else—a combination of fibroma, lipoma, and lymphangioma. Such a case is shown in Fig. 76, page 242, Vol. I.

The diagnosis of the parasitic forms may sometimes be made by finding the parasites in the blood, either at night or during the daytime, according to the variety of filaria causing the condition. In some cases of *multiple infections* the adult worms have been found in the discharge from a *lymph fistula* of the scrotum or lower extremity, in the fluid of hydrocele, in the epididymis, the spermatic cord, the inguinal and other lymph nodes, etc.

The signs and symptoms of the disease from whatever cause are characteristic. There is a slowly developed enormous hypertrophy, affecting especially the skin and subcutaneous tissues. The limb becomes at first swollen, the skin and subcutaneous tissues gradually become more and more thickened. As time goes on the limb becomes greatly deformed; massive, irregularly shaped tumors are produced in addition to the general enlargement of the limb. The surface of the skin becomes roughened, horny, and thrown into folds. In the creases between these folds dirt and the secretions of the skin collect and undergo decomposition, producing excoriations, eruptions, inflammations and ulcerations. The individual suffers greatly from itching and often from pain

referred to the areas of distribution of sensitive nerves compressed by the newly formed fibrous tissue. The putrid discharges from the crevices and ulcerated surfaces give off a horrible, stinking odor, so that the patient may become an object of disgust to himself as well as to others. As time goes on, attacks of erysipelatous inflammation are common, and these lead to an increase of the swelling and to an added production of fibrous tissue. The limb may become so increased in size that locomotion is very difficult. Partly as the result of deficient nutrition and partly from want of use, the muscles of the limb and even the bones undergo a high grade of atrophy. A complicating synovitis in the knee- and ankle-joint may occur. The progress of the disease is apt to be marked by intermissions in many cases. In the parasitic cases the onset may be quite acute. The patient may be taken severely ill with rigors, fever, and prostration, and the lesion in the extremity may more or less resemble an acute cellulitis complicated by lymphangitis. The process, however, does not end in suppuration, and after a few days the acute attack subsides, leaving behind a more or less circumscribed or diffuse mass of induration. Other attacks of a similar character follow at irregular intervals, each one resulting in an increase in the size of the limb, and such attacks may be separated by a period of weeks or months, during which the progress of the disease comes to a standstill. Beginning in the parasitic cases, usually between the fifteenth and thirtieth year of life, many years may elapse before the condition reaches its height. Patients may live, with a progressive increase in the size of the limb, for five, ten, fifteen years or more. The disease may be unilateral or bilateral. The only difficulty in diagnosis lies between the parasitic and the nonparasitic forms, and it is to be made from the data already given.

The only treatment which affords even a palliation of the condition is the operative removal of thick wedges of skin and subcutaneous tissue, the long axis of the wedge being directed transversely across the limb rather than in its length. Amputation has been done in a few cases where the limb became so large that locomotion was impossible. Ligation of the femoral artery has been tried, but is not worthy of serious consideration, since gangrene of the limb has followed in certain cases and in others the local conditions have scarcely been improved. The prognosis as to cure of elephantiasis is unfavorable.

ANEURISMS OF THE ARTERIES OF THE LEG

Aneurisms of the anterior and posterior tibial arteries are relatively rare. The largest proportion of them are of traumatic origin and they occur with about equal frequency in the anterior or posterior tibials, less often in the smaller arterial branches of the leg. The traumatic cases follow fractures of the bones of the leg, either simple fractures or those which are compound by direct violence, such as run-over accidents or gunshot wounds. In the traumatic cases with the immediate production of an arterial hematoma, a deep-seated tumor will be formed quite rapidly and will give the signs of traumatic

aneurism as in other situations. Owing to the deep position, however, of these vessels, it will often happen that the signs of aneurism will be obscured, and if the blood constituting the tumor has largely undergone coagulation, a murmur may be absent. After the aneurism has reached a certain size it will usually pulsate and pressure upon the femoral artery in the groin will cause the pulsation to cease. In many instances the pressure upon the veins of the limb will give rise to obstruction in the venous circulation and marked swelling, even to gangrene of the foot. Pressure upon the nerves will cause pain, paresthesiæ, and sometimes disturbance of motor function in the muscles. Aneurisms of the tibial vessels have been mistaken for abscesses and for sarcomata. As a complication of fracture of the bones of the leg, rupture of the tibial vessels or the peroneal has been recorded in a fairly large number of cases. Stimson [1] states that he has "seen hemorrhage occur from the anterior tibial on the eighth day after fracture by direct violence without displacement; the rupture was one and a quarter inches above the fracture and was evidently due to bruising of the artery by the wheel which caused the fracture." If the wall of the vessel is only moderately bruised, the development of the aneurism may be delayed, here as elsewhere, for many days or weeks. The treatment of these traumatic aneurisms is exposure of the sac, evacuation of the clots, and ligation of both ends of the affected vessel. If a sac has formed with definite boundaries, it may be extirpated.

ACUTE OSTEOMYELITIS OF THE BONES OF THE LEG

The *tibia* is, of all the bones in the body, the most frequent seat of acute suppurative osteomyelitis, being affected in about two fifths of all cases. The original focus of infection is usually in the spongy tissue near one or other of the extremities of the shaft of the bone, whence the infection spreads to the medulla up or down the shaft. Secondary involvement of the epiphyseal cartilages is not rare and spontaneous fracture may occur. The knee- and ankle-joints may become the seat of a serous, sero-purulent, or purulent inflammation. The microörganisms producing this disease are here, as elsewhere, most commonly the Staphylococcus pyogenes aureus, and yet a number of other organisms may be responsible for the condition. Thus the Bacillus typhosus during convalescence from typhoid fever not infrequently invades the bones. The pneumococcus may also cause osteomyelitis as may Bacillus coli and other forms. In the cases produced by Staphylococcus pyogenes aureus the course of the disease is apt to be more acute and stormy and will lead more often to a rapidly fatal septico-pyemia than when the bone is invaded by the other forms mentioned. The Bacillus typhosus especially is apt to produce a subacute osteomyelitis, and yet such is not always the case, notably if the typhoid bacillus is associated with other strictly pyogenic forms. The so-called *periostitis albuminosa* and *sclerosing osteomyelitis*, though both of them rather rare, are

[1] L. A. Stimson, *loc. cit.*, p. 384, 1907.

more often observed in the tibia than in other bones. (For a description of these conditions see Vol. I, page 186.)

The general signs and symptoms of acute purulent osteomyelitis of the long bones have been repeatedly described in other parts of this book, and for them the reader is especially referred to the section on acute osteomyelitis in Vol. I. The tibia lying superficial throughout its whole extent, permits an early recognition of the local disturbances. The local signs and symptoms of the disease are here developed early and are well marked. To recapitulate them briefly, they are: Agonizing, boring, tearing pain referred to the leg with extreme local tenderness most marked over the origin of the process. Interference with the venous circulation causes swelling of the limb and sometimes dilatation of the superficial veins. There is total loss of function in the extremity. A localized swelling of the bone occurs when the periosteum is invaded, and this will be more or less circumscribed, or may occupy nearly the whole length of the shaft, according to the extent of the process in the bone. After invasion of the periosteum, swelling of the soft parts occurs and the skin and subcutaneous tissues overlying the front of the tibia become edematous and pit upon pressure. Invasion of the overlying soft parts is attended by greater swelling and by a dusky or bluish discoloration of the skin.

FIG. 234.—OSTEOMYELITIS OF THE TIBIA; TOTAL NECROSIS OF THE DIAPHYSIS OF THE BONE; AN INVOLUCRUM HAS FORMED COMPLETELY INCLOSING THE SEQUESTRUM. Cloacæ exist here and there through which the necrotic shaft is visible. (Anatomical Laboratory of the College of Physicians and Surgeons, Columbia University, Medical Department.)

The inflammatory infiltration of the soft parts will also vary in extent according to whether the process is confined to some particular part of the bone or extends throughout the entire shaft. In the latter group of cases the swelling will involve the foot, the leg, and extend above the knee-joint. In these cases also dilatation of the subcutaneous veins is particularly marked. The only condition with which the disease at this stage is likely to be confounded is a phlegmonous inflammation of the soft parts of the limb, and in such cases the surgeon when making his incisions will incise the periosteum. According to the stage of the process, this membrane will be found elevated from the bone by the bloody, purulent exudate, or at an earlier period it may be merely thickened, velvety, and easily separable from the bone. The earlier the operation is done, and the more thoroughly the infected medulla and cancellous tissue are removed and the more perfectly the interior of the shaft is laid open and cleaned out, the less extensive will be the sub-

sequent necrosis and the greater the extent to which the periosteum will reapply itself to the shaft. A certain amount of necrosis is, however, to be expected in all cases. The sequestra will vary in size from one or more superficial thin scales of bone to almost the entire shaft, in severe or neglected cases. In the former instance, though healing is usually delayed for many months, the ultimate functional result is good. In a certain proportion of cases, however, there remain behind larger or smaller foci of chronic infection, consisting of single or multiple areas of purulent infiltration of spongy bone, which come to be occupied later by small irregularly shaped sequestra. This condition may endure, with intermissions, throughout many years, and these patients will come back from time to time with a history of a tender point over some portion of the tibia, pain (worse at night), and in some instances a mild degree of chronic sepsis. In some cases, when the entire shaft, or a large portion of the shaft, becomes necrotic, it will be surrounded by a large involucrum of new bone with cloacæ here and there, leading to sinuses in the overlying soft parts. Such patients, if neglected, may die of chronic sepsis with amyloid degeneration of the abdominal organs. In some, the production of the involucrum of new bone will be imperfect, so that, upon removing the sequestrum, a spontaneous fracture of the shaft occurs, or, in other cases, the involucrum itself will become the seat of a subacute or chronic osteomyelitis. In these, a large portion of the shaft may be lost. In a case of this kind operated upon by Dr. Charles McBurney in Bellevue Hospital in 1886, a good functional result was obtained by cutting a depression in the head of the tibia and transplanting into it the freshened upper end of the fibula. The fibula in the course of a year greatly increased in size, and the patient, a boy of six or seven, was able to walk upon it with only a moderate limp and with very little discomfort.

In some of these cases, notably if not operated upon early, retraction of the soft parts occurs after incision, leaving exposed a large portion of the subcutaneous surface of the tibia, which becomes the seat of a chronic, more or less superficial, osteitis with small circumscribed foci of chronic suppuration in the deeper portions of the shaft. Such cases are very hard to heal, and repeated operations of a plastic character, combined sometimes with skin grafting and other devices carried out through a series of years, may be necessary before healing takes place. One sees other cases occasionally in the hospitals of New York who have recurring attacks of circumscribed subacute osteitis, extending over a period of many years and who are never completely cured.

The *fibula* is less often the seat of acute osteomyelitis than the tibia, yet the former is not very rarely affected. Thus, in the statistics of Bruns's clinic, the tibia was involved in 42.16 per cent and the fibula in 3.10 per cent of all cases of acute osteomyelitis.

Among the *complications* of acute osteomyelitis of the tibia are, as elsewhere described, synovitis of the knee- or ankle-joint, either serous or purulent. The signs of effusion into the joint will be present. Invasion of the epiphyseal

cartilage may cause spontaneous fracture either of the tibia or of the fibula. In these cases union may finally occur with more or less disturbance in the subsequent growth of the bone, or the epiphyseal cartilage may be destroyed and the diaphysis may fail to unite with the epiphysis above. In this last group the attempt may be subsequently made to procure union by freshening the ends of the epiphysis and diaphysis, respectively, and immobilizing the limb in the best attainable position.

As elsewhere described, cases of SUBACUTE OSTEOMYELITIS of the tibia are not very rare. Such may be due to ordinary pyogenic infection, or occur as a complication of typhoid fever, or other infectious diseases. I have observed several such cases complicating puerperal sepsis of moderate severity. In the subacute cases the general and local signs and symptoms are far less stormy. There will be, following some acute infectious generalized process, or without such a history, moderate pain referred to some portion of the tibia, followed by periosteal thickening and a more or less sharply circumscribed fusiform enlargement of the bone. The signs of general infection in these cases may be very slight. Fever may be trifling in amount or absent, the pulse-rate may be normal. Leucocytosis may be so slight as not to be in any wise distinctive. These patients, however, are nearly always anemic, pale, and somewhat emaciated. They never completely recover from the original infectious disease through which they have passed. Owing to the absence of acute symptoms, these cases may be mistaken for tuberculosis. This will be more likely to happen when the focus of infection is situated near either extremity of the shaft. Upon operation the appearance of the pus, the presence of an actual sequestrum, rare in tuberculosis, and the bacteriological examination of the exudate, will establish the diagnosis.

Following osteomyelitis of the tibia, more or less marked disturbances in the growth of the bone may result with the production of deformity. If the epiphyseal cartilage is destroyed the bone will be shortened and the amount of such shortening will depend largely upon the period of growth at which the destruction occurred. If the shortening of the tibia is marked, a deformity of the foot and ankle will occur in the nature of a talipes varus. In other cases the epiphyseal cartilage is not destroyed, but irritated merely. In these an overgrowth of the tibia may occur with the production of a more or less marked valgus. In both of these types the articulation of the fibula with the astragalus is more or less deranged. If the tibia undergoes an overgrowth, the fibula lagging behind, a more or less complete dislocation of the lower end of the bone may occur. (See also Dislocations of the Fibula.) If the tibia fails to grow to its normal length, a more or less marked compensatory curve appears in the fibula.

In regard to the OPERATIVE INDICATIONS in acute osteomyelitis of the tibia, it may be said that the earlier and more completely the septic focus is laid open and removed, the better the chances of the patient's survival and the better the local results. As to the method of operating in the later stages of the disease

for the removal of sequestra, some surgeons prefer to operate very early before the dead bone has separated (Cushing), believing that better results are thus obtained. Other surgeons believe in waiting until the dead bone has separated and then removing it by chiseling away the overlying involucrum. The removal of the sequestra should be followed by curettage of all foci of infection.

TUBERCULOSIS OF THE BONES OF THE LEG

Tuberculosis of the tibia occurs for the most part as a localized embolism situated in the upper or lower epiphysis of the bone. The former situation is the more common. Such localized tuberculous areas in the cancellous tissue run the course of tuberculosis of bone, elsewhere described. Those situated in the head of the tibia, the most frequent site, may eventually perforate into the knee-joint, causing tuberculous arthritis. In a certain proportion of cases, however, the soft parts are perforated outside the joint, with the production of a tuberculous periostitis, a tuberculous cold abscess, etc., and the same is true of tuberculous foci in the lower end of the bone. The early recognition of these conditions is highly important for the individual. If operated upon before the knee- or ankle-joints are invaded, respectively, a cure is probable with preservation of the joint. If operation is delayed until the joint is affected the condition, of course, becomes far more serious. The difficulty in arriving at an early diagnosis in these cases depends largely upon the fact that the early symptoms, as they occur in children, are not very marked. A moderate dull pain referred to one or other condyle of the tibia, or a similar pain referred to the lower end of the bone with slight tenderness upon pressure, may be all the symptoms attracting the attention of the parents of such children, and even intelligent people are apt to lull themselves into a sense of false security by assuring themselves that the moderate pain and slight limp belong in the category of so-called "growing pains." In certain cases the X-rays afford a valuable aid in the diagnosis. Carefully taken pictures will sometimes show a more or less sharply circumscribed area in the upper or lower end of the tibia, respectively, which throws a lighter shadow than the rest of the bone. If plates with such characteristics can be obtained on several occasions, and if, in addition, there is moderate localized pain and tenderness, and especially if periosteal thickening exists causing apparent circumscribed enlargement of the epiphysis, an exploratory operation is indicated. The development of a cold abscess following the invasion of the periosteum, its perforation and infection of the overlying soft parts, renders the diagnosis of a tuberculous infection of the epiphysis quite certain. If, fortunately, the focus is so situated that this result occurs, diagnosis and operative cure are quite possible. In the less favorable cases the focus perforates into the knee- or ankle-joints with the results elsewhere described. Secondary invasion of the tibia from tuberculosis of the knee- or ankle-joints is also possible. The signs and symptoms are those of tuberculous arthritis.

Tuberculosis of the Shaft of the Tibia.—Tuberculosis of the shafts of the long bones is, as elsewhere stated, a far rarer lesion than tuberculosis of the epiphyses. It may, nevertheless, occur in several forms. The tuberculosis of the shaft may be secondary to a primary tuberculosis of the epiphysis. One observes this condition not infrequently when operating upon bad cases of tuberculosis of the knee-joint. In addition to a tuberculous panarthritis of the knee, one discovers a focus of infection in one or other condyle of the femur, and upon further examination the process is found to extend a variable distance up the shaft. I have seen such cases in which the shaft and medulla of the femur had become tuberculous for a distance of six inches or more above the condyles. Such cases are rather unfavorable for permanent cure even by resection, and frequently will require amputation of the thigh. In other and rarer instances small foci of tuberculosis form in the shaft of the tibia, usually near its junction with the epiphysis. In these the process may remain localized with the production of a tuberculous periostitis and cold abscess, or it may secondarily invade the epiphysis, or, on the other hand, become generalized, involving the entire medullary cavity and diaphysis of the bone. Such cases are, however, rare. I recall but one in which the entire shaft of the tibia was the seat of tuberculous infiltration. The diagnosis of these various conditions is to be made from the signs and symptoms elsewhere given of tuberculosis of bone, though often a differentiation from subacute or chronic osteitis of pyogenic origin will not be made until the time of operation. The X-rays may be of some assistance in this group of cases, although, as a rule, before the amount of bony destruction has become so marked as to permit of a probable diagnosis by this means, the soft parts overlying the bone will have been infected and a cold abscess or abscesses will have formed.

SYPHILIS OF THE BONES OF THE LEG

Both hereditary and acquired syphilis produce lesions of the tibia and fibula with great frequency. In the acquired form of the disease *the tibia is of all the long bones the most frequently affected.* The bony lesions occur in several types. They belong to the later rather than to the early stages of the disease in the acquired cases. Most commonly the lesion consists of a gummatous periostitis of the shin-bone. The foci are often symmetrical on both sides of the body, and the bony changes produced are one of the most characteristic diagnostic signs of the disease observable during the lifetime of the patient, although the local lesion is cured. The periostitis occurs most often upon the subcutaneous surface of the tibia and along its sharp bony crest. The lesions are diffuse or circumscribed, and in the latter case often multiple. Somewhat rounded, tender, hard, painful elevations slowly form upon the surface of the bone, and as time goes on, after weeks or months, they form rather prominent, in some cases almost hemispherical, lumps causing a distinct elevation of the skin. The lesion is here, as elsewhere, partly a destructive and partly a productive one. The surface of the bone at the base of the nodule is more or less

eroded, while from the borders of the infiltration a productive periostitis occurs, so that a more or less irregularly cup-shaped depression is formed upon the tibia, surrounded by an irregular elevation of new bone. When these lesions are multiple they may coalesce and extend for a considerable distance up and down the shaft.

The course of the disease varies in different cases. In some cases the gummatous tissue softens, breaks down and perforates the skin with the formation of a rounded, punched-out ulcer, whose base consists of gummatous tissue, or of worm-eaten bone, infiltrated with gummy material. The appearance of these syphilitic ulcerations is quite characteristic to the trained eye. After the process has healed the contours of the tibia are quite changed and this will be especially observed by passing the finger up and down the crest of the bone, when one feels that the sharp regular outline of the crest is lost, the border of the bone feeling nodular, knobby, and irregular. *The cutaneous scars left after the healing process* are also quite characteristic. They are circular in outline and adherent to the underlying bone. At first copper-colored and later white. Their occurrence upon both shin-bones with the concomitant change in the outlines of the crest are absolutely characteristic signs of a former syphilis. In some cases the process is diffuse rather than circumscribed, and in these the entire shaft of the bone will be occupied by a more or less regular swelling, tender on pressure. As time goes on the shaft may be more or less irregularly worm-eaten, or, on the other hand, greatly thickened by the production of new bone. *The peculiar worm-eaten appearance of such bones in combination with the formation of irregularly shaped osteophytes is characteristic of syphilis.*

FIG. 235.—OSTEOPERIOSTITIS OF TIBIA. (Saber leg); Hereditary syphilis. (After Taylor.)

Syphilitic osteomyelitis may also occur in the tibia, either alone or in combination with a syphilitic periostitis. In the former group of cases the gummatous process may be localized and more or less sharply circumscribed in the medulla, or spongy tissue of the bone, or in other cases quite diffuse. The bony destruction in the latter group of cases may be such that spontaneous fracture occurs. In other cases the bony production will greatly exceed the destructive process, so that the tibia may become greatly increased in size and massive.

The *signs* and *symptoms* of syphilitic periostitis and osteomyelitis of the tibia vary to some extent in different cases. In some the patients will complain of but little pain and discomfort in the affected bone. In others pain of a boring, tearing, though usually remittent or intermittent character will occur. *Such pains are quite commonly worse at night* and this character is supposed to be more or less typical of syphilitic bone lesions. They constitute the so-called " osteoscopic pains " of syphilitic bone disease. In addition to the subjective symptoms, the changes in the outline of the bone are usually fairly characteristic. A history of syphilis is usually obtainable in these cases. Some assistance may also be gained by means of the X-rays. The irregular bony destruction, together with the production of new bone, may show in a characteristic manner upon the X-ray plate. While syphilis of the tibia is not usually confounded with other conditions, yet mistakes sometimes do occur. The enlargement of the bone may, as already stated in regard to the femur, be mistaken for a true new growth, nor is a differential diagnosis easily made in all cases. A history of former syphilis, the presence of other syphilitic manifestations, or of syphilitic scars upon other parts of the body, the use of the X-rays, the Wassermann reaction, and a negative reaction to the several tuberculin tests, are useful aids in the diagnosis. When gummata have broken down and crateriform ulcers of characteristic appearance are present, the syphilitic nature of the lesion is plain. In a good many instances the exceedingly chronic course of syphilis will establish the diagnosis in doubtful cases. One sees such syphilitic tibiæ which have been the seat of periostitis and osteitis for many years. The course of tuberculosis and sarcoma is more rapid. Actual new bone, if it is produced, cannot, of course, be made to disappear, but the associated gummatous infiltration of the periosteum and soft parts is usually quite rapidly improved under syphilitic treatment, while at the same time the pains grow less.

Syphilitic Inflammations of the Tibia in Hereditary Syphilis.—Hereditary syphilis may manifest itself in the bones of the leg in several forms. The productive lesions are more common in this form of the disease than the destructive ones, though the latter do occur. In Vol. I, under Syphilis, page 192 and 193, we have spoken of the osteochondritis of hereditary syphilis in children (pseudoparalysis syphilitica—Parrot). The affection is particularly frequent in the tibia. In another group of cases the lesion consists of a productive inflammation involving the periosteum as well as the entire shaft of the bone. The tibia becomes diffusely thickened and enlarged. In some cases the increase in the size of the bone is continuous, in others it occurs as the result of successive irregularly timed attacks of syphilitic inflammation. In addition to the change in size and shape, the outline of the bone becomes quite irregular. During the early stages the periosteal thickening may give rise to a sensation in the examining hand as though the unevenly enlarged bone were soft in one place and hard in another. After the disease is well developed, however, the entire surface becomes of bony hardness. Not only is the size of the bone increased, but very marked curvatures occur, anterior or lateral, and the shape of the bone may be so changed

that it comes to resemble in appearance the anterior curvatures of the tibia observed in rachitis. As the result of the overgrowth of the bone, its length is also increased, and deformities of the foot in the direction of genu valgum with associated flat-foot occur.

A large proportion of these cases run their course without softening of the gummatous material and the formation of sinuses. In certain cases, however, this occurs. Some of the cases are attended by only moderate pain, in others pain of an annoying character is observed, especially at night. The pains vary from time to time in intensity. In the worst cases pain of an agonizing character occurs, so that these patients become worn out from want of sleep and constant suffering. I recall one such case seen many years ago in the Roosevelt Hospital out-patient department, a young girl who when she first came under observation was about ten years of age and who suffered from hereditary syphilis. The disease affected the shaft of the tibia, there was a marked increase in the size of the bone of a diffuse character and from time to time a portion of the syphilitic bone would become necrotic, an abscess would form and the dead bone would be removed by operation not in the form of a separated sequestrum, but as an area of black, stinking, infiltrated, hard bone, which never seemed to separate itself. These operations would be followed by temporary relief, and the wound would close more or less perfectly. This girl remained under observation for a number of years, undergoing many operations, suffering more or less constantly from pain and of such severity that in the end she died worn out and exhausted by loss of sleep and suffering. Treatment of every kind was tried conscientiously with only temporary improvement.

In another section we have described the deformities of the bones of the leg and thigh occurring as the result of rachitis. Their diagnosis is to be made upon inspection and they require no further description here. (See Rachitis, Vol. I.)

CHAPTER XXVII

TUMORS AND CONGENITAL DEFECTS OF THE LEG

TUMORS OF THE LEG

Tumors of the Soft Parts of the Leg.—The various forms of benign tumor are observed in the skin and in the deeper soft parts of the leg. They possess no special characters here. Among them may be mentioned fibromata either in the form of soft fibroma (fibroma molluscum) and hard fibroma (keloid), occurring not infrequently at the sites of former burns and in the scars of operations. They are notably more frequent here, as elsewhere, among the negro race than among Caucasians. They need no special diagnostic description. (See Tumors, Fibroma, Vol. I.)

Lipoma.—Lipoma may occur subcutaneously in the leg, though rarely. Pure lipoma, or combinations of lipoma with fibroma, is occasionally observed as a circumscribed encapsulated tumor in the intermuscular planes of the leg. I recall such a case in the Roosevelt Hospital which was operated upon by Dr. Frank Hartley. The patient was a little child of about four years of age, and the tumor occupied the region of the calf of the leg. It was deep-seated and of considerable size. Owing to its deep situation surrounded by muscular attachments, the tumor was quite immovable and no diagnosis was made other than that of a probable sarcoma, until the tumor was exposed by incision. It somewhat resembled in size, shape, and general appearance, except for its color, a somewhat irregularly formed bologna sausage about six inches in length. Whether the tumor was congenital or not could be learned with certainty. It was completely encapsulated. The diagnosis of fibro-lipoma was made.

Other forms of benign tumor, angioma, whether simple or cavernous, are occasionally observed in the soft parts of the leg. They present the same appearances here as elsewhere. Pigmented moles of the leg may occasionally be the starting point of melanosarcoma. I removed a small tumor about the size of the last joint of a finger from the calf of a man's leg which appeared to be a primary melanosarcoma originating in a pigmented mole. No other tumors were discovered at the time of operation, but within six months the patient was in a dying condition from multiple internal metastases. Endothelioma and perithelioma may arise in similar moles. They run the course of the more malignant sarcomata and require amputation of the limb. Such a case is figured in the text (Fig. 236).

Among the epithelial tumors of the leg of not very rare occurrence are the

FIG. 236.—ULCERATED SARCOMA OF THE POPLITEAL SPACE.
(New York Hospital collection, service of the late Dr. F. H. Markoe.)

EPITHELIOMATA arising for the most part in chronic ulcers of the leg, or in the scars, or in ulcerated ancient scars following burns, or in other similar cicatrices. After the scar or the ulcer has existed for a certain time, usually for many years, a change in the character of the base of the ulcer occurs. Firm massive granulations sprout up from the base of the ulcer, and a hard infiltration of the skin and subcutaneous tissues advances from the borders of the sore. The original ulcer may long remain without increase in size, or in other cases a more or less rapid ulcerative process occurs around its borders. The interesting point about this form of epitheliomatous degeneration is, that in many cases the diagnosis is not made until after the cancer has existed as such for some time. In these cases the fact that the ordinary forms of treatment, rest, elevation of the limb, disinfection,

FIG. 237.—PERITHELIOMA OF THE LOWER THIRD OF THE LEG; ULCERATED. Amputation of the leg. (New York Hospital collection.)

etc., cause little or no improvement in the ulceration and that the firm exuberant granulations continue to be formed, should lead at once to a suspicion of malignant degeneration. A case of this character is described in the preceding chapter, and another is figured upon page 258, Vol. I, and still another upon page 259, Vol. I, the latter having occurred in the scar of an amputation stump.

The various forms of SARCOMA may occur in the soft parts of the leg, and here they give the same signs and symptoms as do sarcomata elsewhere. Rapid growth, immobility from infiltration of the surrounding structures, a surface nodular or smooth, hard or soft, or of varying consistence in different portions of the tumor, but without marked tendency to ulceration, during their early stages. They vary here, as elsewhere, in malignancy and may arise in the skin, the connective-tissue planes, the nerve trunks, the vessels of the limb. Of all these the melanosarcomata are, of course, the most hopelessly malignant.

Tumors of the Bones of the Leg.—Among the benign tumors of the bones of the leg may be mentioned the *osteomata and chondromata and their combinations.* The cartilaginous tumors are more apt to arise at the line of the epiphyseal cartilages, but may occur anywhere on the shafts of the bones. They present the same clinical history here as in other situations and may give rise to few or no symptoms, or, on the other hand, by pressure upon nerve trunks to neuralgic pains. They may interfere mechanically with motion. The case figured in the text (Figs. 238 and 239) shows one of the consequences of an osteoma of the shaft of the tibia growing backward and pressing the shaft of the fibula from the tibia. The figure in the text shows also the very accurate diagnosis which may be made of these tumors by means of the X-rays. Bony tumors are more frequent upon the tibia than upon the fibula, their most frequent situation being upon the inner side of the upper portion of the shaft. They may be multiple. When they grow superficially, they may cause marked inconvenience by their mere mechanical presence. Over them a bursa may develop and this from time to time may become inflamed. The pure enchondromata are rare upon the tibia. Here, as elsewhere, malignant forms are occasionally observed.

Primary epithelial tumors of the bones of the leg do not occur. Carcinoma is observed, however, in the tibia as a secondary metastatic tumor, giving the signs and symptoms of malignant tumors of bone—namely, spontaneous fracture, rapid infiltration of the surrounding soft parts, etc.

Cystic formations are occasionally observed in the tibia. ECHINOCOCCUS CYSTS have occasionally been observed in the tibia. The variety of the disease occurring in the long bones is the echinococcus multilocularis. There is a diffuse development in the medulla of the bone of innumerable small vesicles, there being no mother cyst. There is produced a rarefying osteitis of the cancellous tissue and thinning of the cortical layer of the shaft. Subsequent irritation of the periosteum may lead to a spina ventosa. Spontaneous fracture occurs in certain cases. The disease will usually be mistaken for a chronic osteomyelitis of one or other type, or for a tumor of the bone, if spina ventosa occurs. Other rare cystic tumors of the tibia have been described of non-

parasitic origin. The periosteum of the tibia may in rare cases give rise to lipoma.

Myeloma.—Tumors whose tissue is identical with that of red bone marrow such as is observed in young and growing bones, although rare tumors in any situation, are more commonly observed in the tibia than in any other of the long

Fig. 238.—Osteoma of the Shaft of the Tibia which has Caused a Bending Backward and Partial Absorption of the Shaft of the Fibula. Lateral view. (New York Hospital collection. Case of Dr. Frank Hartley.)

Fig. 239.—Antero-posterior View of Osteoma of the Tibia shown in Fig. 238.

bones. They are not malignant tumors. They are, however, extremely vascular. Upon section the cut surface of the tumor is red in color and may more or less closely resemble the cut section of a congested liver. Under the microscope large numbers of giant cells are observed, such as appear in the medulla of growing bones.

Occurrence.—These tumors are chiefly observed during youth, but may occur at later periods in life. When they occur in the long bones, notably in the tibia, they produce a slow but steadily progressive spina ventosa with thinning of the cortical layers of the bone. Perforation of the corticalis may

occur, and such is the vascularity of these growths that a pulsating tumor of the soft parts is formed resembling the more vascular and pulsating sarcomata. It is possible that in former times, cases of myeloma of the long bones were mistaken for sarcoma, and thus limbs may have been sacrificed unnecessarily. Since the myelomata are not malignant, amputation will scarcely ever be required. Removing of the tumor tissue by scraping and the like is sufficient to effect a cure. As in other conditions producing spina ventosa, when the cortical layer is thinned to the utmost, parchmentlike crackling occurs upon palpation.

In very rare cases FIBROMA has been described as originating in the tibia.

SARCOMA.—The most interesting and important tumors of the tibia are the sarcomata. Here, as elsewhere, they occur in two forms, the periosteal and the myeloid sarcomata, the former being the more malignant, and of the round-celled, spindle-celled, or mixed-celled types, while those originating in the medulla are more commonly of the giant-celled variety.

The periosteal forms originate most often in the shaft, while the favorite site for the myeloid giant-celled sarcoma is in the head of the tibia. Here, as elsewhere, the periosteal forms are characterized by a rapid growth, producing a fusiform or asymmetrical enlargement of the bone with secondary infiltration and destruction of the surrounding muscles and other soft parts. The differential diagnosis in the early stages is difficult, the growth producing few symptoms at first and being often mistaken for one or other of the forms of subacute osteoperiostitis, whether pyogenic, tuberculous, or syphilitic. If the skin is perforated, a fungating, bleeding, soft mass of tumor tissue is formed, constituting one of the conditions formerly known as "fungus hematodes."

The treatment of periosteal sarcomata of the tibia is amputation of the thigh. The medullary sarcomata are, as stated, most common in the upper end of the tibia and the giant-celled forms are the ones usually observed. Though sufficiently malignant, they are not as deadly as the periosteal growths. The tumors produce a more or less rapid infiltration and destruction of the bone sometimes with a more or less marked spina ventosa, though in other cases no notable enlargement of the bone occurs.

I recall a case upon which I operated some years ago, a middle-aged man who had complained merely of a sense of dull pain in the region of the knee. There was a scarcely perceptible enlargement of the upper end of the tibia and a slight serous effusion into the knee-joint. I made the probable diagnosis of tuberculosis of the joint and started to do a resection. I soon discovered the error. The greater portion of the inner condyle of the tibia was converted into tumor tissue and the soft parts of the ham were invaded to some extent. I made an amputation at the middle third of the thigh. The patient has since passed out of observation and his fate is unknown to me. The tumor was a giant-celled sarcoma.

Not only the relatively benign giant-celled forms are observed in the cancellous tissue of the tibia, but also the more malignant types, round-celled, spindle-celled, and other combinations. Spontaneous fracture is often observed

with subsequent infiltration of the soft parts. In certain cases the diagnosis of the giant-celled, less malignant forms, may be made at such a time that resection of a portion of the shaft of the bone may be sufficient to obtain a cure. I have seen such a case operated upon in this manner in the humerus with a good result by Dr. L. A. Stimson. Some of the more malignant forms of sarcoma, as well as the perithelioma and endothelioma, when they arise in the medulla of the long bones, may produce, after perforation into the soft parts, pulsating tumors which may even exhibit such a degree of expansile pulsation that they are mistaken for aneurism. Such growths, however, usually are accompanied by the more or less diffuse enlargement of the bone and they cannot be so far diminished in size by pressure as an aneurism. Moreover, pressure upon the femoral artery does not diminish the size of the growth to the same extent as obtains in aneurism.

CONGENITAL DEFECTS OF THE LEG

The formation of amniotic bands and cords, which, during intra-uterine life, encircle the limb, may produce a congenital deformity of the leg. Such deformities consist of a circular constriction of the limb which may be of any depth. In the slighter cases the constriction consists merely of a furrow in the skin and subcutaneous tissues, with but little if any arrest of development in the deeper parts. In other and more marked cases the constriction may also involve the tendons and muscles, so that the function of the limb is seriously interfered with. In the most severe cases the constriction extends to the bone, so that the portion of the limb below is useless. The recognition of these congenital defects is so simple that they require no further description.

FIG. 240.—ANTERIOR CURVATURE OF THE TIBIÆ OF RACHITIC ORIGIN. (Author's collection.)

Congenital Defects of the Bones of the Leg.—The tibia or the fibula may be wholly or partly wanting at birth, owing to a failure of devel-

opment. The defect is more common in the fibula than in the tibia. It may involve either end of the bone. Defects in the upper end of the fibula and in the lower end of the tibia are said to be more common. If the fibula is defective the unopposed action of muscles will produce a greater or less degree of pes valgus—i. e., eversion, pronation of the foot. In extreme cases the foot may be so far displaced outward that it stands almost at right angles to the leg.

If the lower end of the tibia is wanting, the opposite deformity will be produced and the foot will remain practically a useless appendage. If the upper end of the tibia is wanting, the knee-joint will be imperfectly developed and the fibula will rest somewhere against the outer condyle of the femur. The child is born with the leg flexed and adducted. The limb is practically useless below the knee-joint. In other cases the bones of the leg are complete, but one bone may be shorter than the other, and in these cases marked curvatures occur. In some instances the tibia shows an extreme degree of curvature forward and outward and the deformity may resemble an exaggerated condition of bow-leg. In certain other and more extreme cases the shaft of the tibia will be bent at a sharp angle, suggesting an intra-uterine fracture, and in some cases it may be difficult to say, unless other congenital defects are present, whether or not the deformity has been caused by intra-uterine pressure, or by the formation of amniotic bands and cords acting mechanically, or whether a real fracture has taken place. These deformities are of only moderate surgical interest. In certain cases an arrest of development occurs in the leg, such that the child is born with a stump ending just below the knee-joint, or in some part of the leg, and upon such stumps rudimentary toes may be present, which may or may not contain rudimentary phalanges.

FIG. 241.—RACHITIC BOW-LEGS.
(Roosevelt Hospital, collection of Dr. Charles McBurney.)

Intra-uterine and Intrapartum Fractures.—Intra-uterine fractures of the long bones have in rare cases been produced by external violence on the abdomen of the mother. In other cases no such history has been obtainable and it has been believed that the fractures were caused by intra-uterine muscular pressure.

In some of these, however, as, when a child is born with a separation of epiphysis, it has been impossible to exclude hereditary syphilis as a causati factor, or an undue fragility of the bones, due to imperfect nutrition from a cause. Intrapartum fractures of the long bones may be produced during strumental delivery, or during podalic version, and the bones most frequen broken in these cases are the humerus and the femur, less commonly the ti In a very moderate number of recorded cases the fractures have been produ by the muscular efforts of the mother during the delivery of the child. Th bone gets caught between the head and the hard parts of the pelvis and dur uterine contractions fracture may occur. The occurrence of fracture has some times been accompanied by an audible snap. Nearly all these conditions are easily recognized by ordinary methods of examination and require no separate description. In the cases of congenital deformity of the bones the nature and extent of the defects can be readily demonstrated by X-ray pictures, and the more complete the ossification the more the pictures will show.

CHAPTER XXVIII

INJURIES OF THE FOOT AND ANKLE

ANATOMICAL REMARKS[1]

The Topographical and Bony Landmarks of the Ankle and Foot.—Upon either side of the ankle there project prominently the malleoli. The external malleolus descends half an inch lower than the internal, and the anterior border is half an inch behind that of the inner malleolus. The external malleolus lies opposite the center of the ankle-joint. Inasmuch as the internal malleolus is considerably broader than the external, the posterior borders of both are in the same plane. The tip of the external malleolus is opposite to the posterior calcaneo-scaphoid-joint. In the anatomical position of the body the inner edge of the patella, the internal malleolus, and the inner border of the great toe lie in the same vertical plane. These relations are sometimes a useful guide when dressing fractures of the leg, or after osteotomies, etc., in order to keep the limb in a correct position.

If we inspect the dorsum of the foot, putting the muscles creating *dorsal flexion* in a state of contraction, so that the foot is at right angles to the leg or less, a number of landmarks, tendinous and bony, are to be observed. To the inner side, in front of the inner malleolus, the tendon of the tibialis anticus muscle forms a prominence beneath the skin. Below and external to it another tendon appears, the long extensor of the great toe. Still more external, a bundle of tendons may be observed, the common extensors of the second, third, fourth, and fifth toes. Still more external lies the tendon of the peroneus tertius at about the middle of the external border of the foot. Between the tendon of the long extensor of the toe and the innermost tendon of the common extensor of the other toes, may be felt, under normal conditions, just below the ankle-joint, the pulsations of the *dorsalis pedis artery*. If the foot be placed in the position of marked *plantar flexion*, there may be felt the astragalus projecting slightly. It disappears again when dorsal flexion is resumed. On either side of the bundle of tendons and in front of the malleoli a slight depression is to be noted. This depression corresponds to the anterior portion of the capsule of the ankle-joint, which is here quite thin. In diseases of the joint attended by effusion or thickening of the synovial membrane, and in injuries of the

[1] Partly adapted from Woolsey's "Applied Surgical Anatomy," Gray's "Anatomy," and Merkel.

In some of these, however, as, when a child is born with a separation of epiphysis, it has been impossible to exclude hereditary syphilis as a causative factor, or an undue fragility of the bones, due to imperfect nutrition from an unknown cause. Intrapartum fractures of the long bones may be produced during instrumental delivery, or during podalic version, and the bones most frequently broken in these cases are the humerus and the femur, less commonly the tibia. In a very moderate number of recorded cases the fractures have been produced by the muscular efforts of the mother during the delivery of the child. The bone gets caught between the head and the hard parts of the pelvis and during uterine contractions fracture may occur. The occurrence of fracture has sometimes been accompanied by an audible snap. Nearly all these conditions are easily recognized by ordinary methods of examination and require no separate description. In the cases of congenital deformity of the bones the nature and extent of the defects can be readily demonstrated by X-ray pictures, and the more complete the ossification the more the pictures will show.

the inner border of the foot. Anterior to the tuberosity of the scaphoid a distance of 3 cm. lies the first tarso-metatarsal joint. "It is 2 cm. in front of the inner end of a line drawn transversely across the foot from the base of of the fifth metatarsal bone" (Woolsey).

The Ankle-joint.—The ankle-joint is formed between the tibia and fibula above and to either side, and the astragalus below. It is properly a hinge-joint

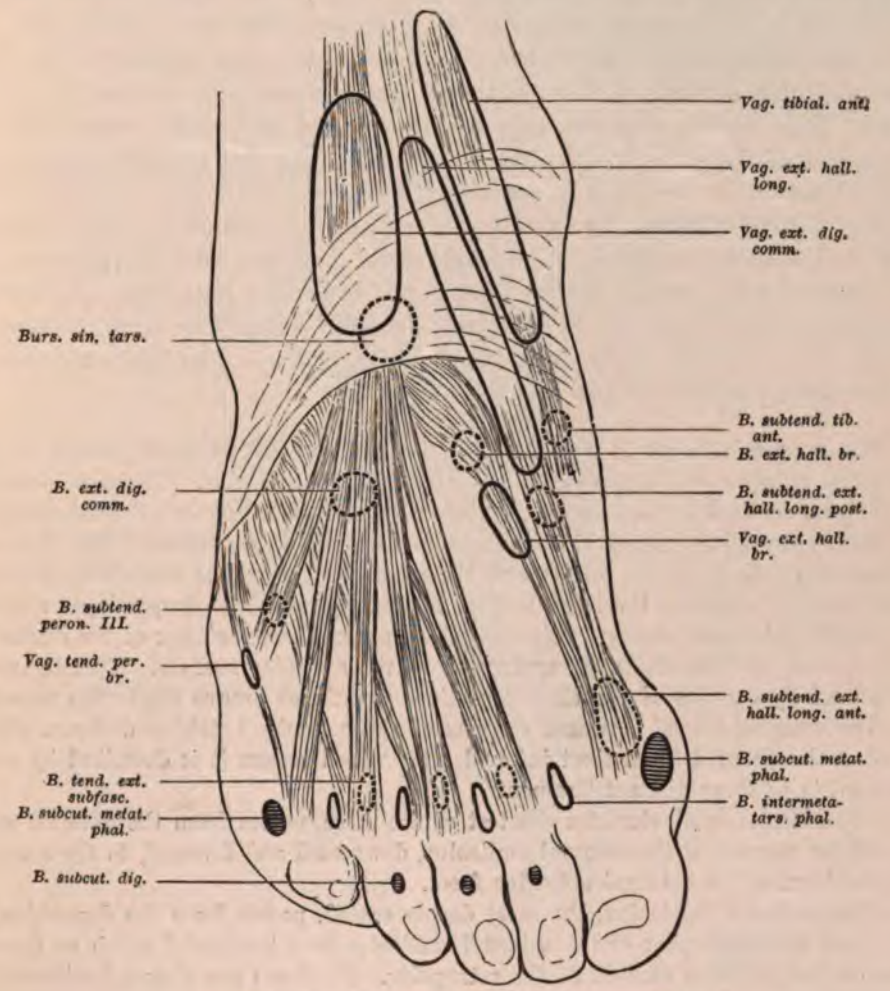
Vag. tibial. ant.
Vag. ext. hall. long.
Vag. ext. dig. comm.
Burs. sin. tars.
B. subtend. tib. ant.
B. ext. hall. br.
B. ext. dig. comm.
B. subtend. ext. hall. long. post.
Vag. ext. hall. br.
B. subtend. peron. III.
Vag. tend. per. br.
B. subtend. ext. hall. long. ant.
B. subcut. metat. phal.
B. tend. ext. subfasc.
B. intermetatars. phal.
B. subcut. metat. phal.
B. subcut. dig.

FIG. 243.—THE BURSÆ OF THE DORSUM OF THE FOOT.
All the commoner locations of the bursæ are indicated. (After Merkel.)

merely, and no lateral motion occurs therein except in the position of extreme plantar flexion. Motion in the joint takes place about a horizontal axis upon a line which is nearly transverse, though its inner end inclines slightly forward. The motions in the joint between the bones of the leg and the astragalus are those of flexion and extension, or of *dorsal* and *plantar* flexion, as they are some-

times called. It is to be borne in mind that while the foot is at right angles to the leg, neither abduction nor adduction is possible in the normal ankle-joint, and that the presence of such movements indicates injury or disease. In making the examination, however, it is necessary that the surgeon should be careful to grasp the astragalus, not the calcaneum, since by the latter method the calcaneum will be moved upon the astragalus, and thus an ignorant or incautious observer might be deceived. The range of dorsal and plantar flexion at the ankle is variously estimated by different observers at from 80° to 90°, the midposition being when the foot is at right angles to the leg. The articular surface of the astragalus forms about one quarter of a cylinder. It is slightly concave from side to side and articulates above with the lower end of the tibia, which exhibits corresponding but opposite curvatures. Lateral motion in the joint is prevented by the malleoli, these grasping with their articular surfaces the lateral surfaces of the astragalus, thus forming what is known as a mortise. The bones of the joint are held in apposition by the internal and external lateral ligaments. Upon the inner side the deltoid ligament passes from the internal malleolus in triangular form, diverging below, to be attached to the calcaneum and astragalus. The ligament consists of two layers, superficial and deep.

The superficial layer is a strong, flat, triangular band, attached, above, to the apex and anterior and posterior borders of the inner malleolus. The most anterior fibers pass forward to be inserted into the scaphoid and inferior calcaneo-scaphoid ligament; the middle descend almost perpendicularly to be inserted into the sustentaculum tali of the os calcis; and the posterior fibers pass backward and outward to be attached to the inner side of the astragalus. The deeper layer consists of a short, thick, and strong fasciculus, which passes from the apex of the malleolus to the inner surface of the astragalus, below the articular surface. This ligament is covered by tendons of the tibialis posticus and flexor longus digitorum muscles.

The external lateral ligament consists of three fasciculi, taking different directions, and separated by distinct intervals; for which reason it is described by some anatomists as three distinct ligaments.

The anterior fasciculus, the shortest of the three, passes from the anterior margin of the summit of the external malleolus, downward and forward, to the astragalus, in front of its external articular facet.

The posterior fasciculus, the most deeply seated, passes from the depression at the inner and back part of the external malleolus to a horizontal notch or depression on the posterior surface of the astragalus. Its fibers are almost horizontal in direction.

The middle fasciculus, the longest of the three, is a narrow, rounded cord, passing from the apex of the external malleolus downward and slightly backward to the middle of the outer side of the os calcis. It is covered by the tendons of the peroneus longus and brevis. (Gray's "Anatomy.")

The *internal lateral ligament* is exceedingly strong, and its middle part, together with the middle portion of the external lateral ligament, holds the

bones of the leg firmly to the foot and resists all displacements. The *capsular* ligament of the ankle-joint is relatively feeble. It is inserted in front pretty close to the borders of the articular cartilages of the tibia and fibula and extends a certain distance between the two bones. The attachment to the neck of the

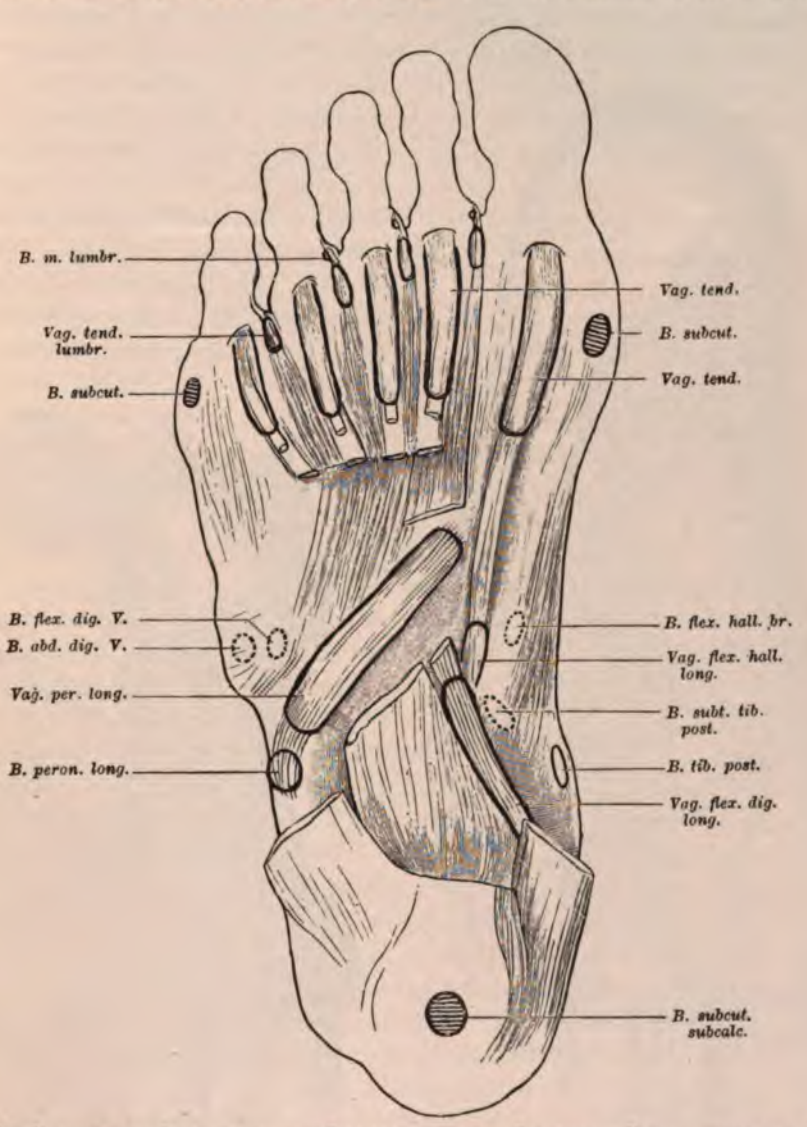

FIG. 244.—DIAGRAM TO ILLUSTRATE THE SITUATION OF THE COMMONER BURSÆ UPON THE SOLE OF THE FOOT. The tendon sheaths are also shown. (After Merkel.)

astragalus, however, is slightly in front of the border of the articular cartilage. The capsule is covered on its anterior surface partly by the extensor tendons, slight projections of the capsule existing between them, forming shallow pockets and folds. Upon *either side of the tendon bundle the capsule of the joint lies*

times called. It is to be borne in mind that while the foot is at right angles to the leg, neither abduction nor adduction is possible in the normal ankle-joint, and that the presence of such movements indicates injury or disease. In making the examination, however, it is necessary that the surgeon should be careful to grasp the astragalus, not the calcaneum, since by the latter method the calcaneum will be moved upon the astragalus, and thus an ignorant or incautious observer might be deceived. The range of dorsal and plantar flexion at the ankle is variously estimated by different observers at from 80° to 90°, the midposition being when the foot is at right angles to the leg. The articular surface of the astragalus forms about one quarter of a cylinder. It is slightly concave from side to side and articulates above with the lower end of the tibia, which exhibits corresponding but opposite curvatures. Lateral motion in the joint is prevented by the malleoli, these grasping with their articular surfaces the lateral surfaces of the astragalus, thus forming what is known as a mortise. The bones of the joint are held in apposition by the internal and external lateral ligaments. Upon the inner side the deltoid ligament passes from the internal malleolus in triangular form, diverging below, to be attached to the calcaneum and astragalus. The ligament consists of two layers, superficial and deep.

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The external lateral ligament consists of three fasciculi, taking different directions, and separated by distinct intervals; for which reason it is described by some anatomists as three distinct ligaments.

The anterior fasciculus, the shortest of the three, passes from the anterior margin of the summit of the external malleolus, downward and forward, to the astragalus, in front of its external articular facet.

The posterior fasciculus, the most deeply seated, passes from the depression at the inner and back part of the external malleolus to a horizontal notch or depression on the posterior surface of the astragalus. Its fibers are almost horizontal in direction.

The middle fasciculus, the longest of the three, is a narrow, rounded cord, passing from the apex of the external malleolus downward and slightly backward to the middle of the outer side of the os calcis. It is covered by the tendons of the peroneus longus and brevis. (Gray's "Anatomy.")

The *internal lateral ligament* is exceedingly strong, and its middle part, together with the middle portion of the external lateral ligament, holds the

apart, this being possible on account of the elasticity of the tibio-fibular ligaments, anterior and posterior. During plantar flexion, on the other hand, the malleoli approach one another. The motions in the ankle-joint are partly limited by the tension of the ligaments and partly by muscular contraction. Thus, when the knee-joint is *flexed,* dorsal flexion at the ankle is possible to a greater degree than when the knee is *extended.* The motion of plantar flexion is limited by the anterior portions of the ligaments, that of dorsal flexion by the posterior parts. A final limitation, however, occurs in extreme dorsal flexion by apposition of the bones, and the same is true of plantar flexion. Since the power of the flexor and extensor muscles moving the ankle-joint nearly balance, and since the position of the bones entering into the joint does not affect the capacity of the joint capsule, effusions into the ankle-joint produce no characteristic attitude.

Articulations of the Tarsus.—The astragalus articulates below with the os calcis, forming two distinct joints, with two distinct synovial sacs, each bone having two separate articular facets, forming an anterior and a posterior joint. A deep groove exists upon either bone between these articular surfaces, the space being filled by a strong *interosseous ligament.* This constitutes the chief bond of union between the bones. In addition, there is an external, calcaneo-astragaloid ligament, a short band passing from the outer surface of the astragalus beneath the border of its articular facet for the fibula, to be attached to the outer surface of the os calcis. This ligament is parallel with the middle portion of the external lateral ligament of the ankle-joint. A posterior calcaneo-astragaloid ligament connects the posterior extremity of the astragalus with the upper surface of the os calcis. Its fibers are directed backward and inward. The synovial membrane for the anterior calcaneo-astragaloid joint is continued forward between the surfaces of the astragalus and scaphoid.

In front, the head of the astragalus articulates with the concave surface of the scaphoid, as well as with the anterior end of the os calcis and with the inferior calcaneo-scaphoid ligament. The movements taking place between the astragalus and os calcis are of a gliding character, from before backward and from side to side. These motions are limited partly by the tension of the ligaments and partly by bony contact. The ligament uniting the astragalus to the scaphoid in front is weak. Behind and below, the inferior calcaneo-scaphoid supplies the place of an inferior ligament. The os calcis articulates with the cuboid in front and the bones are united by four ligaments, a superior and internal or interosseous, a long plantar ligament and a short plantar ligament. The interosseous ligament is short but strong. It rises from the os calcis and is inserted into the inner side of the cuboid. It forms a strong bond of union between the first and second rows of tarsal bones. The long calcaneo-cuboid ligament lies superficial to the short one. It is attached to the under surface of the os calcis, from near the base of the tuberosities and as far forward as the anterior tubercle. In front it is attached to the ridge on the under surface of the cuboid and passes forward to the bases of the second, third, and fourth

metatarsal bones. Between this ligament and the cuboid there passes the tendon of the peroneus longus. The short plantar ligament unites the under surface of the os calcis to the under surface of the cuboid, behind the peroneal groove. It is a broad strong band. The calcaneo-cuboid articulation possesses a separate synovial sac.

The ligaments uniting the scaphoid with the os calcis are two in number. The superior ligament arises with the calcaneo-cuboid ligament and passes forward to the outer side of the scaphoid, forming with the internal calcaneo-cuboid a letter Y. They are separated in front and blended together posteriorly. The inferior calcaneo-scaphoid ligament is the stronger of the two. It passes from the anterior and the inner extremity of the os calcis to the under surface of the scaphoid. " This ligament not only serves to connect the os calcis and scaphoid, but supports the head of the astragalus, forming a part of the articular cavity in which it is received." (Gray's " Anatomy.")

The most important points to bear in mind in relation to the talotarsal joint is, that the motions of adduction and supination occur together, as do those of abduction and pronation of the foot and take place in these joints. The combined motions amount in all to about 40°. That the motion between the astragalus and os calcis is merely a gliding one, from before backward and from side to side; that the astragalo-scaphoid joint is fairly movable and rather feeble, so that dislocation of the astragalus from the scaphoid occurs with considerable ease. Other anatomical details in regard to the foot and ankle will be mentioned in appropriate places.

SPRAINS OR DISTORTIONS OF THE ANKLE

Sprains and distortions of the ankle are among the most frequent injuries. In the beginning, it is to be borne in mind as a matter of the greatest consequence *that a sprain of the ankle is better regarded as, and treated as, a fracture than as a sprain, unless the existence of fracture can be positively eliminated by physical examination and by the X-rays.* There is no more important caution in surgery than this.

Sprains of the ankle-joint may be caused by violence exerted in one or two directions, either abduction or adduction. Sprains by *abduction* are caused by violence which produces an outward rotation of the toes, and at the same time dorsal flexion at the ankle-joint. They are rather less frequent as uncomplicated injuries than the sprains by adduction, since the internal lateral ligament of the ankle is so strong that, in a large proportion of cases, the bone gives way, producing a fracture of the internal malleolus, before the ligament will tear. Still, as described under Pott's fracture, this injury is sufficiently frequent, notably in combination with fracture of the lower part of the fibula. Sprains by *adduction* are much more common as isolated injuries. They occur from violence which turns the foot sharply in the direction of supination. The ligaments most often torn are those between the astragalus and the os calcis,

the anterior portion of the external lateral ligament of the ankle-joint, and the rather weak ligament uniting the dorsal surfaces of the astragalus and scaphoid. In other cases, where supination is combined with adduction, the ligaments between the os calcis and cuboid and between the scaphoid and cuneiform bones may be put upon the stretch, and more or less extensively ruptured. The accident occurs most commonly from an ordinary turn of the ankle. The symptoms produced are pain, swelling, tenderness, loss of function, and ecchymosis. The pain, both spontaneous and upon motion, occurs at once at the time of the accident and is sharp and severe. The swelling develops in a few hours. The ecchymosis, often quite extensive, appears upon the outer and upper part of the foot, and is frequently most marked in front of the external malleolus. I may repeat that in all these cases *the existence of fracture should be eliminated with the utmost care.* In both sprains and fractures, the loss of function in the ankle may be complete or partial, and no positive diagnostic value can be placed upon this symptom.

The most popular treatment of sprain of the ankle at present is that of Gibney, which consists in supporting the ankle by a series of overlapping strips of adhesive plaster, but without completely surrounding, and thus constricting, the limb. Under this treatment the patients are often able to use the joint from the first, and recovery is said to be more rapid than after the treatment by immobilization. If the joint be immobilized in plaster, it is believed that the stiffness due to synovitis and fixation is less rapidly overcome. Early massage and baking, commenced at a very early period, are believed to be valuable measures.

The prognosis of sprains of the ankle varies according to the severity of the injury—i. e., to the extent of the ligamentous rupture, and also with the treatment. In severe cases it may be several months before the normal function of the limb is restored. In slight cases the joint may be well in a week or two.

Chronic Sprain of the Ankle.—In cases untreated, or improperly treated, a sprain of the ankle may not be recovered from for a long time. The ankle may remain permanently weak and painful, or there may be considerable limitation of motion. A good many of these cases are associated with flat-foot and appropriate treatment must be used for this condition. My own preference in the treatment of acute sprains of the ankle, assuming that no fracture is discoverable, is immobilization, with or without the application of wet antiseptic dressings, or an ice bag, until the acute symptoms have subsided, when a dressing of sticking plaster may be applied, and the patient allowed to go about, if the case is not severe. In the more severe cases, physiological rest for the joint, followed after a few days by massage, douching, and baking, have been followed by good results.

INJURIES OF THE TENDONS ABOUT THE ANKLE-JOINT

Dislocations of the Tendons.—The tendons occasionally dislocated in the vicinity of the ankle-joint are those of the peroneous longus and brevis, where they pass behind the external malleolus. The injury is a rare one. It occurs from muscular action, by sudden contraction of the muscles of the calf, usually when the foot is rotated inward. The ligamentous structures, external annular ligament, holding the tendons in place, are ruptured. The patient feels a severe pain in the outer part of the ankle and is unable to walk upon the foot. Upon examination, the tendons may usually be felt riding across the posterior portion of the external malleolus, and can easily be pushed back into place, sometimes with an audible snap. The dislocation, however, is prone to recur upon the attempt to use the limb. As a rule, the tendon or tendons may be easily replaced, and if held in position by a compress and sticking plaster, while the foot is kept in a condition of physiological rest for ten days or more, the dislocation does not recur. In untreated cases, or in some which are not immobilized for a sufficient time, the dislocation may become chronic. These patients suffer from considerable inconvenience in walking and from the disagreeable sensation of feeling the tendons slipping back and forth upon the malleolus. In such cases an open operation and the effort to cover the tendons by ligamentous structures, suturing the torn sheath of the tendons over them, will usually suffice for a cure; a bone and periosteal flap may also be chiseled from the fibula to cover them. Except as a complication of severe fractures in the vicinity of the ankle-joint, the other tendons of this region are very rarely dislocated. Among those individuals who have an extremely relaxed external annular ligament at the ankle-joint, or in whom the bony groove for the tendons is unusually shallow, these tendons may occasionally be dislocated at will. The snapping sound thus produced has been utilized by certain notorious "spirit rappers" for the purpose of defrauding the public. Beach [1] collected and reported eighteen cases in which one or other of the peronei tendons were dislocated. In thirteen of the cases it was the peroneous longus tendon. The accident had occurred in most of the cases from jumping, occasionally from other similar exertions.

A dislocation of the tibialis posticus tendon was reported by Martin. The tendon was dislocated forward in front of the inner malleolus. Although the tendon was readily replaced and remained in position, disability in the foot continued for a long time.

Rupture of the Tendons of the Foot.—Powerful contraction of the tendo Achillis may cause its rupture, or more commonly a portion of the tuberosities of the os calcis is torn away. The symptoms of rupture of the tendo Achillis are, loss or great diminution of the power of plantar flexion in the foot, inability to raise the body upon the toes; there is a hiatus readily palpable

[1] Beach, *Boston Medical and Surgical Journal*, March, 1876.

posteriorly at the back of the heel, or somewhat higher up, in case the tendon itself is ruptured. The tendo Achillis is of such great importance for the function of walking that every effort should be made to unite it when ruptured. In cases which are not seen until some time after the accident, an operation may nevertheless be done and the ends of the tendon brought together, or the tendon again sutured to the os calcis, if necessary, by a plastic operation upon the tendon itself. After two or three weeks the foot may gradually be brought out of extreme plantar flexion until it is at right angles to the leg. The tendo Achillis may also be divided in open wounds, and if the tendon is completely severed the symptoms will resemble those of rupture. If only partly severed, the wound of the tendon may only be discoverable upon inspection, or possibly by feeling a groove or depression in its surface. In case the division of the tendon is an old one, an operation should be done for its restoration and union of the divided ends. In general it may be said that the tendon is so large, and the symptoms produced so characteristic, that the diagnosis offers no difficulty. The other tendons of the foot may be cut by accidental wounds, the tendons upon the dorsum, for example, when a man who is chopping wood strikes a glancing blow with his axe, the blade of which is deflected across the dorsum of the foot. The diagnosis of such injuries is usually simple from the situation of the wound, the resulting disability, and upon inspection. The same rules in searching for divided tendons in the foot apply as is the case with the forearm and wrist (see sections on these topics), although in general it may be said that the tendons of the foot do not retract into inaccessible positions so readily as do the tendons of the wrist and forearm. That tendons weakened by tuberculosis, syphilis, or suppuration are more liable to rupture, goes without saying.

Rupture of the Plantar Fascia.—Rupture of the plantar fascia is occasionally observed as a complication of fractures of the bones of the ankle, foot, and leg. The resulting disability may depend in part upon partial destruction of the antero-posterior arch of the foot, with the production of flat-foot, or, on the other hand, a condition was described by Ledderhose,[1] which he called "fasciitis chronica," a condition affecting the plantar fascia, resulting from injury by blunt violence and from the pressure of plaster dressings, etc. The fascia became hypertrophied and nodular, so that very marked pain and disability in walking resulted. In some of the cases observed the condition resembled more or less closely Dupuytren's contraction of the palmar fascia.

FRACTURES OF THE BONES OF THE FOOT

Fractures of the Astragalus.—The astragalus may be fractured as the result of violence transmitted through the os calcis, as when an individual falls from a height upon the foot, so that the astragalus is crushed between the os calcis and the bones of the leg. It may also be fractured as the result of gunshot

[1] Langenbeck's *Arch.*, vol. liii, No. 3.

wounds or from direct violence, such as run-over accidents and the like. In the last two groups the fracture is only a part of a more or less grave injury, and even in the simpler cases which occur from falls, the fracture is often associated with fracture of the os calcis or of the bones of the leg. In the severer forms, such as occur from run-over accidents and in gunshot wounds, the bone may be more or less extensively comminuted. In those which occur as the result of falls upon the foot the line of fracture may run in various directions. It may be transverse in front of the articular surface for the tibia, the head constituting an anterior and separate fragment, or the line of fracture may run practically in any direction with reference to the long axis of the bone. Comminution also is not rare in this group.

The diagnosis may not be easy by ordinary means of examination; frequently, as related, the fracture is complicated by fractures of other bones, so that the loss of function in the foot is absolute. There will always be localized tenderness over the line of fracture, but it will rarely be possible to localize accurately the presence of crepitation in the astragalus itself, since other near-by fractures may confuse the examiner. In some cases, where the bone is fractured transversely, the main fragment has been displaced backward, so that it projected posteriorly above the os calcis. The presence of a bony prominence in this situation, together with other signs of fracture, would lead the surgeon to a more or less accurate diagnosis, and the same may be said of other cases when the fragments are notably displaced. When no displacement exists, however, the only accurate means of diagnosis, assuming that the fracture is simple, is by carefully taken X-ray pictures. In these cases the pain, tenderness, swelling, ecchymosis, and loss of function will be present, but will not be characteristic. In cases of doubt, therefore, the X-ray diagnosis should be resorted to if possible. In the cases accompanied by notable displacement of considerable fragments, as for example, when the fracture involves

FIG. 247.—FRACTURE OF THE NECK OF THE ASTRAGALUS WITH INCOMPLETE OUTWARD AND BACKWARD DISLOCATION OF THE BODY. (New York Hospital collection.)

separation of a considerable part of the articular surface for the tibia, or when the head is separated with displacement, the surgeon will be justified in making an incision and either removing one or more fragments or replacing them, if conditions seem favorable for union.

The Os Trigonum.—The os trigonum, a small bony nodule attached to the posterior border of the astragalus, sometimes as a bony process, sometimes only joined to the astragalus by cartilage, occurs occasionally as a congenital anomaly. It is usually found upon both feet when it occurs at all. The importance of this bone lies in the fact that as the result of injury to the foot, it may be displaced upward and has been regarded by many, when observed on X-ray plates, as a separated fragment of astragalus, its presence having been interpreted as indicating a fracture. In examining for fractures of the tarsus, the possible presence of this little bone should be borne in mind. When it occurs, it is usually seen in the plate just behind the posterior border of the astragalus.

FIG. 248.—CRUSHING FRACTURE OF THE OS CALCIS PRODUCED BY A FALL FROM A HEIGHT. Note the broadening of the heel and the absence of the normal depressions upon either side of the tendo Achillis. (New York Hospital collection.)

The most recent literature of fractures of the tarsal bones may be found in an article by Hugh Cabot and Horace Binney, *Annals of Surgery,* January, 1907, p. 51; also "Old Fracture of the Tarsus," by Leonard W. Ely, in the same number of the *Annals,* p. 69.

Fractures of the Os Calcis.—The os calcis may be broken in falls from a height, and in these cases the fracture is a true crush of the bone. It may be fractured by direct violence, as from the fall of an iron beam or the like upon the heel. It may be crushed sidewise, as when the foot is caught between a wheel and the curb; it is occasionally fractured by bullets, and may be fractured

by muscular contraction of the muscles attached to the tendo Achillis. In the crushing fractures such as occur by falls from a height upon the foot, the signs and symptoms are pain and tenderness referred to the heel, there is marked swelling of the posterior portion of the foot, there is obliteration of the depressions upon either side of the tendo Achillis, and usually a marked broadening of the heel. The actual lines of fracture are hard to determine without the use of the X-rays. The fractures have been variously classified by different observers. The classification of Cabot and H. Binney appears to me to be practical. It is as follows:

1. The fractures are confined chiefly to that part of the bone lying behind a vertical plane through the middle of the body of the astragalus, and these cases may be subdivided into several groups.
   a. Cases with one large heel fragment.
   b. Cases of small heel fragment corresponding to the avulsion fractures of other authors.
   c. Cases showing cracks or fissures but no actual separation of fragments.
2. Those in which the force of the blow has been expended upon that portion of the os calcis lying beneath the astragalus, in front of the plane mentioned above —i. e., the anterior half of the bone. These fractures are nearly always comminuted.
3. Cases in which the whole os calcis is crushed and extensively comminuted.

As before noted, the actual conditions can only be appreciated by means of the X-rays. In a general way, examination by ordinary palpation does not permit accurate conclusions.

The classification of fractures of the *astragalus* adopted by Cabot and Binney is as follows: The bone may be regarded as consisting of two parts, a protected part and an exposed part, the body of the bone being largely protected by its position between the malleoli. The second part, the neck, is the more exposed to violence, notably to twisting strains or to crushing violence from above and in front. Fractures of the neck constitute the largest proportion of all fractures of the astragalus. In Cabot's cases the neck was the seat of fracture in ten out of fifteen cases where the X-ray plates were good enough to permit an accurate judgment. Half of these were due to falls, the other half to direct violence.

Fractures of the body are due to similar kinds of violence to those producing crushing fractures of the os calcis. They vary in character. The bone may simply be broken in two, or entirely crushed. An accurate diagnosis can only be made by means of X-ray pictures, or by an open operation.

Fracture of the Sustentaculum Tali.—A rare fracture of the os calcis. In the reported cases the injury has been produced by sudden strong inversion of the foot. After the fracture the foot assumes the position of *valgus*. There is marked pain and disability. The heel may appear a little shortened. Among Cabot's cases of fracture of the os calcis, fracture of the sustentaculum tali was observed in a number of instances in that group of fractures accompanied by

comminution. As an isolated injury it has been diagnosticated in ery few cases.

ure of the Os Calcis by Muscular Action.—This fracture is an avulsion tion of the os calcis by violent contraction of the muscles attached to Achillis. In some cases a small portion only of the bone close to the nt of the tendon is torn away. In others a considerable fragment. The

—Fracture of the Os Calcis. Fall from a height. (New York Hospital collection.)

nent may be slight or marked. In the latter group of cases the smaller may be drawn up several inches above the heel. The symptoms those of rupture of the tendo Achillis—namely, loss of the power of lantar flexion of the foot. The diagnosis is usually quite easy. The ristic disability is unmistakable and the larger or smaller bony frag- be felt on palpation of the region of the heel or just above it.

ures of the Scaphoid and Fractures of the Cuboid.—These are exceedingly solated injuries; a very few cases only have been described. Fracture

of the former has been produced by indirect and direct violence, fracture of the latter alone is so extremely rare that Stimson [1] says that he knows of but one case, a patient in the Hudson Street Hospital. "The fracture was caused by a blow on the outer side of the foot; crepitus was distinct on pressure of the fragment against the cuboid."

Fracture of the Metatarsal Bones.—Fractures of the metatarsal bones are usually produced by direct violence, such as blows upon and crushing injuries of the foot. They may, however, be produced indirectly, as in such muscular efforts as jumping, dancing, and the like. As fractures by direct violence they are quite commonly seen in hospitals and dispensaries as the result of the fall of heavy bodies upon the foot, or occasionally from a horse stepping upon the foot. Frequently, when due to these causes, two or more of the metatarsal bones are broken.

Fracture of the tip of the base of the fifth metatarsal bone has been observed by Lillienfeld, quoted by Stimson, in several cases produced, it is believed, by inversion of the foot by muscular contraction of the peroneus brevis muscle.

The diagnosis of fracture of the metatarsals in the cases produced by direct violence is usually easy. There is, as a rule, marked swelling and ecchymosis of the foot, disability, or great pain in walking, and localized tenderness at the point or points of fracture. The displacement is usually slight, but in some cases an irregularity may be palpated upon the dorsum of the foot corresponding to a displacement of one or other of the fragments. These fractures, if simple, usually heal readily without marked resulting disability. If compound, it goes without saying that they may be very serious injuries indeed, since the contused tissues are a favorable soil for pyogenic infection. Fractures of the phalanges of the toes are usually produced by direct violence and are often compound. Their diagnosis is entirely simple by ordinary methods of examination.

DISLOCATIONS OF THE ANKLE

For the anatomical relations of the bones and ligaments see the preceding section. Dislocations of the tibio-tarsal articulation are extremely rare as isolated injuries. They occur in an incomplete form with great frequency, associated with fractures of the lower ends of the tibia and fibula. The dislocations may take place backward or forward, outward or inward.

Backward Dislocations.—Backward dislocations are more frequent than forward ones, the cause being extreme plantar flexion of the foot. The injury may be produced by the individual falling backward while the foot is held in a fixed position. The limit of normal plantar flexion having been reached, the astragalus brings up against the posterior border of the tibia. If the violence is continued, the lateral ligaments are ruptured and the astragalus together with the foot slips backward a variable distance, at the same time that the foot resumes a position of less marked flexion. The fibula may at the same time be

[1] L. A. Stimson, *loc. cit.*, p. 406, 1907.

broken, and if this is the case its lower fragment is displaced backward with the foot.

The diagnosis is not difficult. The front part of the foot appears shortened while the heel appears lengthened and more prominent. The anterior border of the lower end of the tibia appears as a sharply marked prominence on the front of the limb. The malleoli appear notably prominent on either side, and their distance from the posterior surface of the heel is increased. The extensor tendons appear as a bundle of tense cords readily palpable upon the front of the joint, the tendo Achillis is prominent behind and the depth of the depressions upon either side in front of it is increased. The position of the front part of the foot is not characteristic. It may be straight or either adducted or abducted. Loss of function in the joint is complete. In nearly all cases the dislocation has been easily reduced by pulling the foot forward and pushing the tibia backward.

Forward Dislocations at the Ankle-joint.—Forward dislocation of the ankle is a very rare injury indeed, far more rare than the preceding variety. The injury may be produced in two ways. First, by extreme and forced dorsal flexion of the foot, sometimes aided by a force acting upon the tibia, either in its long axis or to press it directly backward. In other cases the injury occurs from two forces, one of which acts upon the heel to press it forward, the other upon the lower end of the tibia to press it backward.[1] The injury is not infrequently compound, and the displacement may be complete or incomplete. The bones are not usually fractured, or, if fracture occurs, it is more apt to be of the internal than of the external malleolus. The deformity is the opposite to that in the backward dislocations—namely, the heel is shortened and appears less prominent, and the front part of the foot is lengthened. The distance between the malleoli and the posterior border of the heel is diminished. The cylindrical articular surface of the astragalus is palpable in front. The foot may be in a position of plantar flexion. The cases are so few that not very much can be said in regard to treatment, except that pushing the foot backward and pulling the tibia forward would probably succeed in most cases.

Dislocation Inward.—Two forms of this dislocation occur. The first is characterized by marked inversion of the foot (supination), such that the articular surface of the astragalus lies beneath the external malleolus. The second form is characterized by a rotation of the foot upon a vertical axis, such that the toes are directed inward in a position of adduction. The supination of the foot is less marked or absent. Both forms are commonly accompanied by a prying outward of the external malleolus by the upper and outer border of the cylindrical surface of the astragalus. The fibula may be fractured through the malleolus, or at its base. In a number of instances the injury has been compound. The external malleolus may project through a tear in the skin. The cause of the dislocation has usually been a fall upon the foot from a height.

[1] L. A. Stimson, *loc. cit.*, p. 817, 1907.

The diagnosis is to be made by the peculiar deformity, and by recognizing the absence of the astragalus from its normal position between the tibia and fibula, and its presence as recognizable by the contour of its articular surface upon the outer border of the foot.

I may say once and for all in regard to obscure fractures and dislocations of the bones of the ankle and the foot that, if seen early, while there is but little swelling, it is sometimes possible to make an accurate diagnosis by ordinary means of examination. In other cases this will not be so, and in these, stereoscopic X-ray pictures give the most satisfactory results. The reader will, therefore, understand that while the X-rays will not be again especially mentioned in this connection, they are far the easiest and most certain means of diagnosis in these, at times, rather obscure injuries.

Dislocations Outward.—These are, as has been related when describing Pott's fracture, exceedingly common associated lesions in fractures of the lower ends of the bones of the leg. The dislocation has occurred without fracture. Thomas Wendell, quoted by Stimson,[1] collected twenty-seven cases uncomplicated by fracture. Nineteen he called dislocations by pronation, and eight dislocations by eversion. Fourteen of the cases were compound. In the dislocations by eversion the attitude of the parts are thus described by Stimson:

> The sole is everted, sometimes looking almost directly upward; the astragalus lies under the internal malleolus, or obliquely across the mortise, or, in compound cases, may be external to the external malleolus. The malleoli are separated.

In another group of cases the foot is markedly abducted, so that the toes point directly outward, or nearly so. Thus Stimson[2] describes a case which he saw in the Hudson Street Hospital, a man who had injured his right ankle by slipping on the sidewalk an hour previous. The case presented the following signs:

> The foot was abducted nearly 90°, and over the internal malleolus the skin was tightly stretched, and almost the entire articular surface of the tibia could be easily palpated. The fibula was separated from the tibia below and pushed backward by the foot; it was broken at the middle, without displacement. Reduction was easy by traction and adduction of the foot.

Dislocation Upward.—In this very rare form the astragalus is forced upward between the tibia and the fibula.

A fairly large proportion of dislocations at the ankle-joint are very serious injuries indeed, since they are often compound and are associated with multiple fractures of the bones of the leg, sometimes of the tarsus, and with serious laceration of the blood-vessels and the soft parts. The diagnosis of these complicated injuries is sometimes difficult. If seen early they may be treated, as has elsewhere been described in speaking of complicated wounds of joints, conserv-

[1] L. A. Stimson, *loc. cit.*, p. 819, 1907.

[2] *Ibid.*, p. 820, 1907.

tively. With great care as to the cleansing of the parts, aseptic healing may often be obtained. In bad cases care should be used to keep the foot at right angles to the leg and neither pronated nor supinated, so that should ankylosis occur the foot will be in its most useful position. If the wounds become infected they must be treated by free drainage, by removal of the astragalus, by resection, or in the worst cases by amputation.

SUBASTRAGALOID DISLOCATIONS

Dislocation of the os calcis from the astragalus, with simultaneous dislocation of the scaphoid from the astragalus, leaving the latter in position in its articulation with the tibia and fibula, may occur in four directions—namely, inward, outward, forward, and backward.

Dislocation Inward.—The violence producing the dislocation has usually been a fall from a height acting to produce adduction and inversion of the foot. Stimson states [1] that:

> The displacement is rarely, if ever, directly inward, but is also somewhat backward, so that the head of the astragalus rests upon the cuboid.

The dislocation may be compound, the lacerated wound occurring upon the outer side of the foot, through which the external malleolus may protrude, or even the head of the astragalus. The signs and symptoms of the dislocation are, the sole of the foot looks inward, the toes are adducted, the leg appears to be displaced anteriorly with reference to the foot—that is to say, the heel appears lengthened and the front part of the foot is shortened. The external malleolus is prominent and near it

FIG. 250.—SUBASTRAGALOID DISLOCATION OUTWARD. Anterior view. (New York Hospital collection.)

[1] L. A. Stimson, *loc. cit.*, p. 821, 1907.

may be seen and felt the head of the astragalus. The internal malleolus appears to be more deeply placed than normal, the sustentaculum tali can be palpated behind and below the malleolus, while in front of it may be felt the scaphoid bone.

FIG. 251.—SUBASTRAGALOID DISLOCATION OUTWARD. View from behind. (New York Hospital collection.)

Dislocations Outward.—The entire foot below the astragalus is displaced outward, sometimes with abduction of the toes. The astragalus remains in its normal relations to the tibia and fibula. In a considerable proportion of the cases the dislocation is compound upon the inner side, so that the head of the astragalus projects through a wound in the skin. In the directly outward variety the whole foot is displaced bodily outward. The position more or less closely simulates that of an ordinary Pott's fracture, the internal malleolus being very prominent, but in addition the head of the astragalus forms a marked projection upon the inner and dorsal aspect of the foot. The scaphoid may be palpated and instead of the prominence behind it normally created by the head of the astragalus a depression exists.

Dislocation Backward.—Well-marked forms of this dislocation are extremely rare. The most notable and most carefully studied and described case was that of Professor Carmichael, reported by Macdonald.[1]

Carmichael, in his effort to avoid a fall when his horse stumbled and came upon his knees, leaned back in the saddle and thrust his feet forward; his weight was received upon the inner side of the ball of the right foot, and the dislocation was thereby produced, the deformity being so great that it was recognizable through his boot. The toes were abducted about 30°, the foot slightly everted; the con-

[1] Macdonald, *Dublin Quarterly Journal Med. Sci.*, 1838, vol. xiv, p. 235. Quoted also by Stimson, *loc. cit.*, p. 824.

cavity of the tendo Achillis was manifestly increased and the heel lengthened; the astragalus could not be felt behind the tibia. Below and in front of the inner malleolus was a hard prominence, over which the skin was tense, formed by the inner surface of the astragalus. The most striking deformity was a prominence on the dorsum of the foot; "immediately in front of the tibia it presented a flat surface broad enough to receive the finger, from which there was an abrupt descent upon the anterior part of the tarsus. Over the projection caused by the head of the astragalus thrown on the upper surface of the scaphoid and cuneiform bones, the integuments were so tense that it was very evident a small additional force would have driven it through the skin." The distance from the internal malleolus to the end of the great toe was one inch less than on the other foot. No fracture could be found. Flexion and extension were very painful. The dislocation was reduced by traction with the pulleys and direct pressure on the heel and leg.

Dislocation Forward.—This extremely rare injury has been in the reported cases, with two exceptions according to Stimson, associated with fracture. In some the signs and symptoms have been very marked and the displacement considerable. In others the displacement has been slight. In the more marked cases the heel is shortened, the front part of the foot lengthened. The distance between the external malleolus and the tendo Achillis is notably diminished. The prominence of the heel is partly or almost totally lost. In one of the cases reported in which no fracture coexisted, Parise's patient, quoted by Stimson,[1] the history of the injury and the condition at the time of the examination were as follows:

> The patient was injured by being crushed under a heavy weight, the thigh being flexed on the trunk, the leg on the thigh, and the foot on the leg (dorsal flexion). Nine months afterwards the condition was as follows: The foot was at a right angle with the leg, a little adducted, and very slightly everted; it was displaced forward, so that it appeared lengthened in front, and the external malleolus almost touched the tendo Achillis. The extensor tendons on the instep were tense, and no prominence could be felt beneath them, but on the outer side a bony prominence could be felt, which was thought to be the head of the astragalus, and immediately in front was a depression which admitted the finger. The hollow between the astragalus and calcaneum seemed to be filled. Behind, the prominence of the heel was completely lost, the leg flattened, and its surface interrupted at the level of and a little below the malleoli by a bony prominence which raised the tendo Achillis and overlapped the heel nearly half an inch; above it was another, less prominent, formed by the posterior articular edge of the tibia. There was no trace of fracture, no separation of the malleoli. There was slight motion in the tibio-tarsal joint; motion in the joints of the tarsus was entirely lost. The patient could hardly walk without crutches.

The diagnosis of these dislocations can, as already indicated, be best made by means of the X-rays. The physical examination may be extremely difficult on account of the associated swelling, so that the most accomplished surgeon

[1] L. A. Stimson, *loc. cit.*, p. 825, 1907.

may be at a loss to correctly interpret the physical signs revealed by palpation. The important points to be borne in mind are that the normal relations and motions of the joint between the astragalus and the bones of the leg are preserved, and that no lateral motions of the astragalus itself can be made. The front part of the foot and the heel appear lengthened or shortened according to the direction of the displacement. The motions of the subastragaloid joints are either increased or limited. The bony points which continue to bear their normal relations are the head of the astragalus and the malleoli, whereas the relations of the os calcis and scaphoid to the astragalus and the malleoli are disturbed, as may be recognized more or less clearly by palpation if the swelling be not too great. As a rule these dislocations are not difficult to reduce, but if difficulties are found, an aseptic operation with search for the obstacles to reduction and their relief under the control of the eye are proper measures to pursue.

DISLOCATIONS OF THE ASTRAGALUS

Total dislocation of the astragalus is a more frequent form than either dislocation of the tibio-tarsal joint or of the subastragaloid joints. The directions in which the astragalus may be dislocated are numerous. They are, namely, forward, outward and forward, inward and forward, inward, backward, and lastly dislocations by rotation. In a considerable proportion of cases the dislocations are compound. The injury is produced by falls from a height upon the feet, combined with a twisting strain. Why in one set of cases the injury should be followed by dislocation of the astragalus, and in another by one or other of the varieties of fracture occurring at the ankle-joint, no man knows. The mechanism is that the ligaments holding the astragalus in place are ruptured by the twisting strains to which the foot is subjected, and that the weight of the body transmitted through the astragalus forces the bone out of position.

Forward Dislocations.—These are extremely rare and two absolutely undoubted cases only are described by Stimson.[1] In one there was fracture of both malleoli, the posterior surface of the astragalus looked directly forward. In the other the dislocation was compound, the head of the astragalus projecting through the wound anteriorly. There were other fractures and the extensor tendons were ruptured.

Dislocation Outward and Forward.—This is the most common form of dislocation. The entire astragalus is displaced forward prominently upon the dorsum of the foot. The head may be felt projecting in front of the scaphoid or even as far forward as the base of the fifth metatarsal bone. The foot is adducted and supinated. In one case which came under my observation some years ago, an X-ray picture of which is shown in the text, the history of the accident and the subsequent results, if, as I have no reason to doubt, the patient told me an entirely truthful story, were so remarkable that they are here given. While

[1] L. A. Stimson, *loc. cit.*, p. 829, 1907.

driving in his carriage he stopped the horses for some purpose, and being young and active, jumped out to one side to the ground. In doing so he turned his ankle violently and suffered severe pain. He was, if my memory serves, wearing a low shoe. He perceived that he had hurt himself severely, and upon removing his shoe and stocking discovered that his entire astragalus had escaped from a lacerated wound upon the outer side of his foot and was hanging merely by one or two thin shreds of ligamentous tissue. He hopped into his carriage again, drove home, and sent for a surgeon, who removed the almost entirely separated bone. No special antiseptic measures were used and the foot was put up in a simple wet dressing. Primary union occurred in the wound, and when I saw him six months later he walked without perceptible limp and suffered little or no discomfort. The conditions were as shown in the X-ray picture.

FIG. 252.—TOTAL COMPOUND DISLOCATION OUTWARD OF THE ASTRAGALUS. X-ray picture by the author. Good functional result. Case described in the text

Dislocation Inward and Forward.—In this group of cases the astragalus forms a marked prominence in front of or below the internal malleolus. Rotation about a horizontal axis occurs, the head of the bone projects downward and forward. The foot is in the position resembling flat-foot—namely, in a position of pronation and abduction, or in other cases it is displaced directly outward. The dislocation may be compound and may be associated with fracture of the malleoli.

Dislocation Inward.—A single case is reported by Seiter:[1]

The astragalus lay directly beneath the internal malleoli and had been so rotated that its lower surface looked inward. A free incision was made and the bone restored to its place. The internal malleolus and sustentaculum tali had been broken. Recovery with good function.

Dislocation Backward.—This is a rare form of injury, a considerable proportion of the cases being associated with fracture of the neck of the bone, and in

[1] Quoted by L. A. Stimson, *loc. cit.*, p. 830, 1907.

FIG. 253.—DISLOCATION OF THE ASTRAGALUS OUTWARD AND FORWARD. The dislocation was caused by a twist of the ankle, and was readily reduced by manipulation. (New York Hospital collection, service of Dr. Frank Hartley.)

these the anterior fragment may retain its position, while the body of the bone is displaced backward. In the reported cases the backward displacement has been associated in some with a displacement inward or outward. The signs and symptoms are that a marked depression exists behind the scaphoid where the head of the astragalus ought to be and the astragalus itself forms a marked prominence posteriorly beneath the tendo Achillis, or to one or other side. Stimson notes that persistent flexion of the terminal phalanx of the great toe has been observed in three of the reported cases. The diagnosis is usually quite simple and the reduction not difficult.

Dislocation by Rotation.—Stimson divides this form of dislocation into two groups or varieties—namely, rotation upon a vertical or transverse axis combined sometimes with rotation upon an antero-posterior axis, the bone remaining, nevertheless, in great part between the malleoli and a second group in which rotation has occurred upon an antero-posterior axis merely, while the bone remains almost completely in the grasp of the malleoli. The signs and symptoms of the dislocation will vary somewhat in different cases. There may be associated injuries, such as

FIG. 254.—LATERAL VIEW OF THE SAME CASE. (Dislocation of the astragalus. Fig. 253.)

fracture of the external malleolus. The union between the tibia and fibula may be broken. The degree of rotation has varied in different cases. In those where rotation has taken place upon an antero-posterior axis, rotation has been observed up to 180°. The signs and symptoms have varied so much in the reported cases that I do not elect to take the space to describe them. Traction, pressure, and manipulation have succeeded in causing reduction in a great many cases. If reduction fails, an aseptic operation may be done to remove the obstacle to reduction under the control of the eye and to replace the bone, or if this be impracticable to remove it. The prognosis of compound dislocations treated conservatively has not been very good. Suppuration with ankylosis or amputation or death has resulted in a good many cases.

MEDIOTARSAL DISLOCATIONS

Dislocation of the scaphoid and cuboid from the astragalus and os calcis is a rare injury. It may occur from direct violence as in run-over accidents, or in falls from a height. The scaphoid and cuboid may be displaced backward, so that the head of the astragalus projects in front of the scaphoid and the os calcis upon the upper surface of the cuboid. Displacement in the opposite direction may also occur. The deformity in an old case reported by Ward and quoted by Stimson was as follows: [1]

> The foot presented a remarkably twisted appearance, the anterior part being directed considerably inward, and the inner edge somewhat elevated. The dorsum was shortened one inch. The anterior ends of the calcaneum and astragalus projected distinctly on the dorsum. The external malleolus had been fractured.

In one of the reported cases the dislocation had occurred outward. Loss of the arch of the foot to the extent of a convexity of the sole has been observed. The cases produced by direct violence have usually been associated with fractures.

Dislocations of the Other Bones of the Foot.—Isolated dislocation of the os calcis has been reported. A few cases of isolated dislocation of the scaphoid either forward or inward have been observed. The cuboid dislocations have usually been associated with the dislocations of other bones. The cuneiform bones may be dislocated separately or together. The recognition of these conditions is usually not difficult on anatomical grounds.

DISLOCATIONS OF THE METATARSAL BONES

The metatarsal bones may be dislocated *en masse* and the dislocations may occur in any one of four directions—upward, inward, downward, or outward. They are rare injuries, most commonly produced by direct violence, and since the bony deformities are readily made out on palpation on anatomical grounds,

[1] L. A. Stimson, *loc. cit.*, p. 836, 1907.

the diagnosis is not difficult, unless obscured by very great swelling. When marked displacement occurs the front part of the foot may appear notably shortened. Dislocations of but one metatarsal are more common in the first than in the other four. The most common form of displacement has been upward, although it may be outward. Stimson states that in the reported cases a frequent cause has been a fall while riding a horse, the pressure of the stirrup against the inner and under surface of the bone having produced the dislocation. The diagnosis of all these dislocations is sufficiently easy.

Under the head of MORTON'S DISEASE is described a subluxation of the head of the fourth or third metatarsal bones attended by a falling of the transverse arch of the foot and accompanied by pain referred to the interval between the third and fourth toe-joints, or radiating to the last joint or plantar surface of the fourth toe. The condition is ordinarily known as ANTERIOR METATARSALGIA, or MORTON'S PAINFUL TOE. It is supposed to be due to the wearing of improper shoes, notably shoes which are too narrow and which inhibit the use of the toes themselves as additional supports to the foot. The pain is often of a sharp and neuralgic character, in addition to which there may be burning and tingling sensations in the affected toe of considerable severity. The disease affects women more often than men. One of the characteristic features of the condition is that when the pain occurs the individual has an almost uncontrollable desire to remove the shoe and rub the affected toe. The pain may be felt whenever the patient walks, or only at intervals, or only when certain sizes and shapes of shoes are worn. I have myself suffered from it when wearing moccasins and tramping in the woods. In addition to the pain there may be tenderness over the metatarsal joint. The cause of the affection is supposed to be undue lateral pressure causing the crowding together of the heads of the metatarsal bones. The affected metatarsal bone may be forced upward above its fellows, thus producing a subluxation. The treatment is the wearing of proper shoes and the support of the arch by a suitable metal plate, massage, and special exercises to restore the arch and to develop the muscles of the toes are sometimes of use.

Congenital dislocation of the ankle-joint has been reported in a very few cases. In a series of cases shown by Kraske the disease was hereditary and occurred in a father and two sons. The deformity was due to a congenital defect of development in the fibula with the production of a very marked valgus and great weakness in the ankle. The muscles of the leg were poorly developed. (See also Congenital Defects of the Leg.)

DISLOCATIONS OF THE TOES

Dislocation of the metatarso-phalangeal joint of the great toe is usually caused by such forms of violence as produce sudden hyperextension of the toe. Such may be a fall upon the foot when in marked plantar flexion, the great toe being extended, or from such hyperextension produced by kicking some

rigid body. The dislocation may be directly backward or backward and to one side. Occasionally the injury is compound with the projection of the articular end of the metatarsal bone through the skin to the inner and under side of the joint. The flexor tendon may be dislocated in such a manner as to produce great difficulty in reduction, so that an open incision may be necessary. The diagnosis is quite simple; the base of the phalanx rises prominently upon the dorsum of the metatarsal bone, or to the one or other side thereof. The phalanges may be in a position of hyperextension or lie parallel with the metatarsal bone. In the dislocations outward and upward, or inward, the base of the phalanx will be recognizable as a sharp prominence in corresponding positions. When the dislocation is compound, the projection of the articular end of the metatarsus through a slit in the skin of the sole can be recognized on inspection. The injury is sometimes associated with sprains or subluxations of other neighboring joints.

The terminal phalanx of the great toe may be dislocated, the phalanx is displaced dorsally by hyperextension. The injury may be compound. The diagnosis presents no difficulties. The four outer toes may be dislocated in combination. The dislocation has usually been upon the dorsum of the metatarsus, or occasionally outward displacement merely has been observed. The injury may be compound. They are very rare injuries, rarer even than dislocation of the distal phalanx of the great toe. A dislocataion of the second phalanx of the third toe has been reported.

THE DIAGNOSIS AND SURGICAL INDICATIONS IN SEVERE TRAUMATISMS OF THE ANKLE AND FOOT

Severe crushing injuries of the foot accompanied by multiple fractures of the bones and contused and lacerated wounds of the soft parts are frequent and very serious injuries. While the diagnosis of these conditions is usually entirely simple if aided by the X-rays, the operative indications require a high degree of skill and experience for their proper fulfillment. Among uncleanly persons the skin of the foot is often the home of infectious germs of one sort or another, and further, from the nature of the accidents, producing severe injuries of the foot, the wounds are very frequently infected by street filth, by soil and dirt which swarms with germs of suppuration, and also in certain regions with the bacilli of tetanus, or their spores. Such injuries are quite commonly so complicated that disinfection of the wound is impracticable. They are, therefore, followed in a good many cases by suppuration and in not a few instances by phlegmonous, necrotic spreading processes, which threaten the patient's life, unless early amputation be performed. (See Diseases of Wounds, Vol. I.) The joints of the ankle are so numerous and the individual joints either communicate one with the other, or are close together, that infection in one is frequently followed by infection in several adjoining articulations. Such infections can rarely be treated successfully by ordinary drainage. Resection

of one or more joints, or the removal of one or several of the tarsal bones, may be followed by better results. Infection of the tendon sheaths of the foot are also very difficult to treat. The subcutaneous tissues and fascial layers of the foot are extremely dense, and it is hard indeed to relieve the tension of inflammatory processes and provide for adequate drainage by incisions of any nature. In the less complicated wounds of the foot which become infected, we may, by early incision and careful treatment, avoid serious loss of function in the limb. It is to be borne in mind that infections of the ankle-joint itself are sometimes best treated by removal of the astragalus. If one or other of the smaller joints is involved alone, resection of the whole or a part of one of the bones of the tarsus may furnish adequate drainage. Thus, in a case coming under my care some years ago, a boy aged eleven ran a nail into the joint between the astragalus and the scaphoid. The nature of the injury was not at first recognized, and the joint became infected. I saw the patient about five days after he was hurt. I drained the joint at first by a simple incision, but this was not sufficient to overcome the infection, and I was obliged to remove the scaphoid bone. This was followed by speedy convalescence and the functional result was exceedingly good, a very slight limp merely remaining at the end of a few months.

The especial caution which is to be borne in mind in the treatment of complicated injuries of the foot and ankle is, that infections here usually require heroic measures.

Gunshot wounds of the bones of the ankle are grave injuries on account again of the danger of infection of the several joints. The injury produced to the bones of the tarsus by bullets vary here, as elsewhere, with the character of the missile, its velocity, etc., as elsewhere described. Small leaden pistol bullets may perforate the astragalus or os calcis with but little comminution. (See Vol. I, p. 25.) In this case the wound remained aseptic and there was little or no resulting loss of function in the injured joint. Large rifle bullets of soft lead will usually produce such a degree of comminution of bone as to require an extensive resection, or if infection occurs, often amputation. Jacketed rifle bullets may, at long ranges, cause simple perforations, while at short ranges they are apt to produce rather widespread destruction of bone. These injuries, even though they may remain aseptic, are frequently followed by marked stiffness in the joints, by excessive callus formation, by adhesions of the tendons to their sheaths, and more or less marked resulting disability. This will especially be true if the wound passes through the foot from side to side, so as to impair or destroy the antero-posterior arch. In those cases which become infected and require amputation, notably in wounds involving the ankle-joint itself, it is to be borne in mind that an amputation of the leg at the point of election gives the best stump for the fitting of an artificial limb. If the patient is in such a walk of life that he probably will be unable to procure an artificial limb, Pirogoff's amputation gives a useful stump. In all the cases treated conservatively the foot should be placed at right angles to the leg and neither

abducted nor adducted, so that if ankylosis takes place the foot will be in the best possible position. In regard to injuries of the metatarsal bones and toes, it is to be borne in mind that the loss of one or more of the smaller toes is not a matter of great consequence. The loss of the great toe, on the other hand, is a very serious injury indeed, and this will be more especially true if the ball of the foot also must be removed.

CHAPTER XXIX

DISEASES AND TUMORS OF THE FOOT AND ANKLE

DISEASES OF THE SOFT PARTS

THE acute *superficial* inflammations of the skin and subcutaneous tissues of the foot and toes are less frequent and less important than the similar lesions upon the hand. Ordinary furuncles and larger abscesses on the skin of the foot are occasionally observed. Such may arise from superficially infected abrasions. The origin of such abscesses is in many instances the infection of a corn. The pus accumulating beneath the dense mass of horny epithelium causes exquisite pain. The diagnosis is readily made on inspection and palpation.

A form of superficial ulceration occasionally occurs at the bottom of the clefts between the toes. They may arise from excessive sweating of the foot during the hot weather, or from want of cleanliness. On the other hand, a considerable number of cases occur among persons who bathe very frequently. In these, the frequent bathing, combined with perspiration, causes a softening and maceration of the epithelium which is followed by the formation of a minute fissure. In this latter group of cases less frequent bathing and the use of a dusting powder of talcum, together with the insertion of a pledget of aseptic cotton between the toes usually causes speedy cure. In other cases stroking the base of the fissure with a stick of nitrate of silver will cause it to heal. In this connection it is important to bear in mind that the spaces between the toes are not infrequent sites for *syphilitic moist papules.* The appearance of the lesions, however, is quite different from that of simple ulceration. The essentially chronic character of the disease, the smeary, unwholesome surface of the papules, the presence of a syphilitic history, or of other syphilitic manifestations are usually sufficient for a diagnosis.

Upon the sole of the foot, as upon the palm of the hand, infections not infrequently occur beneath blisters, caused by prolonged walking or by walking in improper shoes. In some cases the infection remains confined to the surface of the cutis. In others it extends into the subcutaneous tissues. In this latter group, we find superficially a blister containing pus, and the blister having been cut away a minute orifice is found at its center perforating the skin and communicating with a smaller or larger abscess cavity in the subcutaneous tissues.

The *deeply seated* suppurative processes of the sole of the foot proceed most often from infected wounds of the sole itself, whether punctured, incised, or

gunshot wounds; less commonly from infections of the toes. The conditions in the sole of the foot resemble those in the palm of the hand. The connective tissues are extremely firm and dense, and although abscesses of the sole are intensely painful, no very marked swelling of the sole is observed during the earlier stages of the infection. *The tissues upon the dorsum of the foot,* on the other hand, are more lax and the swelling and cellulitis spread rapidly from the sole to the dorsum, producing redness, edema, and other signs of pyogenic infection. An unskillful or careless observer may be misled as to the seat of the pyogenic focus and assume that it is upon the dorsum of the foot, whereas in reality it lies beneath the plantar fascia in the sole. The most important guide to the center of the pyogenic focus is the spontaneous pain and *the extremely severe pain produced by pressure with the finger over the abscess.* The tissues of the sole are so dense that the sign of fluctuation is scarcely observed, unless the entire sole is converted into a bag of pus. It should be borne in mind that the deep-seated processes of the sole tend to infect the tendon sheaths and to travel along the tendons to the leg, as do similar processes in the hand and forearm. Here, as elsewhere, the treatment of such abscesses or phlegmonous processes is early free incision for the relief of tension, and care should be exercised in making such cuts to place them as far as possible in situations which will not subsequently be pressed upon during walking—namely, along the borders of the foot, or in that portion of the sole beneath the instep where normally little or no pressure occurs. Further, the cut or cuts should be made with due regard to the position of the tendons, so that these may not be injured.

FIG. 255.—X-RAY PICTURE OF A NEEDLE EMBEDDED IN THE BALL OF THE FOOT BENEATH THE GREAT TOE. The stereoscopic pictures permitted the relations of the needle to the bone to be distinctly appreciated. (Author's collection.)

Callosities and Corns.—The formation of *callosities* upon the sole of the foot and upon the pressure bearing surfaces of the toes is a very frequent condition. Under ordinary circumstances such callosities are of no great moment. When,

however, they have become excessive, they may be painful from pressure upon the nerve endings in the true skin. Their diagnosis presents no difficulties. As already noted, when the tissues beneath such callosities become infected the resulting abscess is unusually painful. The formation of callosities can best be prevented by wearing properly made shoes which fit the feet without cramping them, and by discarding shoes which produce undue pressure at any point.

Perforating Ulcer of the Foot (*Mal perforant*).—A peculiar form of callosity on the foot is quite commonly observed in cases of locomotor ataxia. These patients are not conscious of undue pressure upon the foot in walking or standing, and at one or other point, frequently beneath the metatarso-phalangeal joint of the great toe and beneath the same joint of the fifth toe, callosities form, usually, in my experience, of a more marked character than occur in normal feet. As time goes on such a callus becomes tender and painful. Upon inspection, at the center of the callus will be observed a dark, black, or purple area. If the horny epithelium be cut or shaved away, there will be found at the center of the callus a small collection of extravasated blood, and beneath that the papillary layers of the cutis will be found in a condition of superficial ulceration. If now the patient lies up and does not walk upon his foot for a time, the minute ulcer speedily heals, but always with the production of new callus formation which remains somewhat tender and painful. Presently, or after years, a small deep-seated ulcer forms in the true skin beneath the thickened layers of horny epithelium, and upon inspection it will be found that the ulcer is a little larger and a little deeper than during previous attacks. On this occasion, perhaps, the ulcer becomes infected, the patient has a moderate cellulitis around it which may extend upward upon the dorsum of the foot. He will then be confined to bed for a week or more.

This series of events repeats itself from time to time until there is developed a well-marked trophic ulcer. Such an ulcer usually heals readily enough as the result of rest and protection, but as soon as the patient again uses his foot it breaks down, becomes tender, painful, inflamed, and deeper. These ulcers may finally invade the tendon sheaths, the bones, and the joints, and under such circumstances, they will sometimes necessitate the amputation of one or more toes. I have had several cases of this kind under my care during a period of years. In some of them, I have found it necessary to amputate first one toe and then another upon either foot, until four or five toes have been removed, the entire process extending over a period of a number of years, and slowly growing worse with the progress of the disease. In a few cases the ulcerative process is more rapid and may at an early date invade the bone, or one or other of the metatarso-phalangeal joints. In still others, if the condition is neglected, the ulceration may take on a gangrenous character with more or less extensive destruction of the soft parts, though this in my experience is a rare accident.

Corns.—Corns, like ordinary callous formations, follow, as a rule, pressure from improperly fitting shoes. They are a very common ailment, and cause a good deal of suffering in certain cases. The horny layers of epithelium are piled

up over a circumscribed area. In the center of the corn the horny layer usually projects downward in a somewhat conical form into the papillary layers of the true skin, and this conical mass of horny epithelium constitutes the so-called heart or root of the corn. As already stated, when infected, the small abscesses beneath such corns may be extremely painful. In some cases a minute bursa forms beneath the corn and its infection may give rise to an exceedingly painful abscess. In some cases infection of such a bursa leads to infection of the deeper structures, the subcutaneous tissues, tendon sheaths, with more or less serious consequences. In other cases where such a bursa has become inflamed and has been opened or has ruptured, a minute sinus sometimes persists. If the little sinus becomes plugged, the exudate within the bursa will accumulate and cause a renewal of the acute inflammatory process. The treatment of such bursæ is extirpation.

Syphilis.—The foot is scarcely ever the site of the primary lesion of syphilis. The secondary and tertiary manifestations of the disease, however, occur here with considerable frequency. First, may be mentioned the scaly plantar syphilides which differ in no particular from those observed on the palm of the hand. (See Syphilis, Vol. I.) As already stated, the spaces between the toes are not infrequently the seat of moist secondary syphilitic papules. The plantar syphilides are occasionally accompanied by the formation of fissures and superficial ulcerations with notable hypertrophy of the surrounding horny epithelial layers. Such lesions may be extremely painful. They might possibly be mistaken for inflamed simple callosities. Tubercular syphilides may also occur, notably upon the dorsum of the foot, as well as tertiary gummatous ulcerations which run an extremely chronic course, occasionally in the form of the so-called serpiginous syphilides. The diagnosis of the various syphilitic lesions must be made from the data given in the chapter on Syphilis in Vol. I.

The So-called Madura Foot (Mycetoma) or Fungus Foot of India.—This is a chronic infectious disease observed more often in the foot than elsewhere in India and other tropical countries, and characterized by the production of a chronic inflammatory process attended by the formation of much fibrous tissue, with the formation of abscesses and sinuses, from which are discharged certain yellow or black granules, consisting of one of two forms of fungi. *Two types of the disease* are described, in one of which the granulations are *yellow* and in the other they are *black*. The granules are known respectively as *ochroid* granules and as *melanoid* granules. The yellow granules are conglomerations of the *actinomycosis* fungus, and the lesions produced do not differ here from those in other parts of the body. The black granules, on the other hand, are of a different character and are due to another fungus. The black granules are of firm consistence, irregular shape, and resemble, so it is said, grains of black gunpowder. According to J. H. Wright:[1]

[1] Osler's "Modern Medicine," Vol. I, p. 345.

They consist of a mass of hyaline refringent, brown-colored, brittle substance, forming a matrix in which are embedded a tangle of fungus tubules or hyphæ with doubly contoured walls and transverse septa. This fungus of the melanoid form of the disease has been isolated in cultures by the writer from a single case. This is very probably the only instance in which its cultivation has been accomplished, for Carter's claims that he had grown the fungus in cultures do not bear critical examination. The writer obtained a growth of the fungus from about twenty-five out of approximately sixty-five of the black granules experimented with in this case.

The mode of entrance of the parasite into the tissues is not known. The disease is endemic in certain districts in India, especially in Madura, and has been observed in Africa, Italy, and other tropical or subtropical countries. It seems to be acquired in the country districts and not in towns. In America it is of very rare occurrence, only four undoubted cases having been reported, and three of these were of the pale variety of the disease, which, as has been pointed out above, is to be regarded as actinomycosis.

As observed, the inflammatory process is of a very chronic character, and is characterized by the formation of one, and later, of other firm nodules in the sole of the foot. Abscess formation follows with the discharge of a thin pus and of the characteristic granules. The process tends slowly to invade the surrounding tissues and the sinuses show little or no tendency toward healing. Owing to the absence of cleanliness and the hot climate, the discharges from the sinuses undergo a stinking decomposition. The disease is not notably painful. As time goes on the foot is greatly increased in size and may become quite useless, so that the muscles of the leg undergo atrophy. The condition may readily be confounded with sarcoma, or with syphilis, and the diagnosis depends, of course, upon the recognition of the characteristic granules in the discharge. Spontaneous cure of the disease is unknown.

Tuberculosis.—The various forms of tuberculous infiltration and ulceration are observed in the soft parts of the foot, sometimes as a primary condition, and sometimes as the result of secondary invasion from the bones and joints. The several forms of lupus, whether the papillary or hypertrophic type, occur upon the foot with some degree of frequency. They are to be recognized by the ordinary signs of tuberculosis elsewhere described, and in cases of doubt by one or other of the tuberculin tests, or microscopic examination of excised portions of tissue. In the ulcerative forms, extensive destruction of the skin, the tendons, the muscles, and even of the bones may be observed, with deformity and marked disability. In the cases which go on to partial healing, the deep ulcerations may involve the tendons and their sheaths and produce irremediable malpositions of the foot of one kind or another. If the tuberculous ulceration surrounds the vicinity of the ankle-joint, cicatricial contraction may seriously impair the lymphatic and venous circulation and produce a hard edema of the foot, such as has been described as resulting also from chronic ordinary ulceration.

Ainhum.—A peculiar disease affecting the fifth toe and confined almost exclusively to the negro race. It occurs in tropical and subtropical countries, notably in Africa and South America. The disease is characterized by the formation of a thickened ring of epithelium surrounding the base of the little toe in a circular manner. A constriction forms at this point which gradually increases in depth involving not only the soft parts, but also the bones, so that finally the little toe is strangulated by the pressure, and comes to be attached to the foot by a narrow pedicle which in the end sloughs, producing a spontaneous amputation. During the constricting process, the distal portion of the toe undergoes a more or less marked swelling, the nutrition of all the tissues is impaired, including the bones, and the latter may be completely absorbed, notably the terminal phalanx. The duration of the disease is very long, from one to many years. As a rule, but little pain is complained of unless ulceration occurs followed by infection, when the ordinary signs and symptoms of cellulitis of the foot will be produced. The cause of the disease is obscure. There is no treatment other than amputation. Although the disease has been observed in white persons, it is among them extremely rare.

DISEASES AFFECTING THE TOE NAILS

Marked hypertrophy of the toe nails is observed occasionally in elderly people. The condition usually affects the nail of the great toe, less often of the fifth toe, and the disease is usually bilateral. I have seen such cases among dispensary patients, usually elderly women and among old women who had been bedridden for a long time. The nail may grow to large proportions and may curve upward toward the dorsum of the foot or downward over the lower end of the toe. Such a nail may be two inches or more in length and one half inch thick. The cause of the disease is probably in most instances chronic irritation, the result of pressure from improper shoes. In the cases I have seen, it was usually associated with bunion.

Onychia.—Inflammations of the skin bordering the nail and of the matrix of the nail are less common in the foot than in the hand. When it occurs the signs and symptoms and course of the disease are identical with those observed in the fingers, as already described under Diseases of the Hand. The disease may run an acute course as the result of ordinary pyogenic infection, with the production of a small abscess near the border of the nail and between the nail and its matrix. In other cases the course is more chronic, and may extend over a period of many months. The affection is often extremely painful. The nail is often lost.

Syphilitic inflammations of the matrix of the nail occur during the secondary period of the disease, the end phalanx of the toe is swollen, the folds of skin at the sides and base of the nail are more or less infiltrated, the nail turns black, from beneath the nail there exudes a thin muco-purulent discharge, and in neglected cases such discharge may give off a very disagreeable odor.

The symmetry of the lesion since it frequently occurs on both feet, and the presence of other syphilitic manifestations, together with the very chronic course, usually suffice for a diagnosis.

TUBERCULOUS ULCERATION of the matrix of the nail is occasionally observed. It is characterized by a chronic course, by the formation of a tuberculous granulation tissue of a pale, flabby appearance, and by the bluish and purplish discoloration of the skin at the borders of the ulceration. The diagnosis is to be made from the presence of other tuberculous lesions, from the extremely chronic course, from the more or less characteristic appearance of tuberculous granulation tissue, by means of tuberculin tests, etc.

The formation of a *corn* beneath a toe nail is a somewhat unusual but very painful affection. Pressure upon the nail causes exquisite suffering. The nail is more or less raised from its bed by the piled up epithelium. The treatment of this very painful condition consists of cutting away so much of the nail as is necessary for the complete operative removal of the corn.

SUBUNGUAL OSTEOCHONDROMA.—A peculiar bony and cartilaginous tumor, originating in the terminal phalanx of the great toe upon its dorsal surface, and growing outward in such a manner as to lift the toe nail from its bed and produce rather marked deformity, is the so-called osteochondroma of the terminal phalanx of the great toe. The disease is almost entirely confined to young persons from ten to fifteen years of age or thereabouts. The character of the tumor is readily recognized from the history of its slow growth, from its stony, hard consistence, from the age of the patient, and from the appearance of the rounded, somewhat pinkish tumor mass as large as a pea, or even as large as the last phalanx of the little finger, firmly attached to the bone, pink in color, covered by a layer of horny epithelium, and beneath that by a thin layer of cartilage inclosing a central bony growth. The age of the patient is very important in the diagnosis.

Ingrowing Toe Nail. (*Unguis incarnatus*).—By ingrowing toe nail we understand the growth of the nail in such a manner that it is overlapped by the soft parts at the sides or end of the toe, and produces at first mechanical irritation, with subsequent pressure ulceration and more or less marked infection. The disease affects almost exclusively the great toe, and the outer side thereof is more frequently affected than the inner. The condition is commonly associated with more or less marked deformity of the nail, though such is not necessarily the case, the essential portion of the lesion being a crowding up by external pressure of the folds of skin at the sides or end of the toe, such that they come to cover in the nail.

The cause is almost invariably the wearing of improperly fitting shoes, so that the toes are crowded together against the side of the nail. A concomitant factor in many instances is the habit of cutting the toe nail improperly, especially the habit of trimming the nail upward toward the matrix on either border, and the habit of cutting the nail too short or with a notably convex border. The disease may be avoided by the wearing of proper shoes and by

trimming the toe nail carefully, straight across at right angles to the long axis of the toe and not cutting it at the sides. In cases where the growth of the toe nail itself is abnormal, ingrowing toe nail may occur occasionally without the aid of external pressure by improper footwear. Such cases are, however, exceptional. According to the presence or absence of ulceration and infection, the appearance of the toe will vary somewhat in different cases. In slight cases one or other of the folds of skin at the sides of the nail will be found as a prominent ridge overlapping the border of the nail without signs of ulceration or inflammation, and the symptoms complained of will be pain and tenderness on walking. After ulceration has occurred, the toe will be found swollen, reddened, and from beneath the folds of skin there will escape a thin muco-purulent discharge from the ulcerated surface. The diagnosis is, of course, absolutely simple.

The treatment of ingrowing toe nail is Cotting's operation, or some one of the more recent modern modifications thereof. Conservative methods of treatment are, in my experience, rarely successful. They may be and frequently are palliative for a time; but most of these cases come to an operation before they are cured. It is to be borne in mind in regard to the operation, that it is rarely necessary to interfere with the nail. It is usually better to confine the cutting to the soft parts. In case, however, the nail is greatly deformed, so that it projects laterally far down on either border of the toe, a portion of the nail may be removed at the time of the operation and a corresponding part of the matrix carefully dissected out, so that no nail will grow from the operated part.

DISEASES OF THE TENDON SHEATHS OF THE FOOT

The tendon sheaths of the foot may become the seat of suppurative processes from precisely the same causes as in the hand and forearm. Such infections are, however, rather more rare in the foot than in the hand. They may arise from suppurative or ulcerative processes of the toes, or from infected wounds of the toes or sole of the foot. As in the hand, these processes show the same tendency to advance into the deeper structures of the sole of the foot and cause a more or less widespread phlegmonous inflammation. These conditions are to be recognized from the data already given—namely, from the presence of pain, tenderness, *swelling, more particularly upon the dorsum of the foot,* and by the history of a wound or some infectious process. The treatment consists of free incision for the relief of tension.

Topographical Anatomy.—The topographical anatomy of the tendon sheaths of the foot may be seen in the illustrations from Merkel shown in the text (Figs. 242 and 244). The following details are adapted from Hartmann ("Chir.-topogr. anat. d. Sehnenscheiden," etc., Bruns's *Beitr. z. klin. Chir.,* Bd. 14, S. 408). The tendon sheath of the common extensor of the toes begins 3½ cm. above a line which unites the tips of the malleoli in front and ends 1½

fingers breadth beneath this line, opposite the middle of the third cuneiform bone. The tendon sheaths are covered in front by the anterior annular ligaments of the ankle-joint below and by the prolongation of the deep fascia of the leg above. The anterior annular ligaments are two in number, an upper and a lower one. The upper ligament passes across the front of the ankle between the anterior borders of the tibia and fibula, and serves to bind the extensor tendons together and keep them in place. The lower ligament begins at the outer border of the os calcis and divides into two layers, one of which passes behind and one in front of the extensor longus digitorum tendon and the tendon of the peroneus tertius. The two bands unite at the inner border of the extensor longus digitorum and again divide into two branches, one of which passes to the front of the internal malleolus, the other to the scaphoid and the plantar fascia. This lower ligament holds the tendons in contact with the front of the ankle and prevents them from riding forward when their corresponding muscles contract. The lateral annular ligaments unite the posterior borders of the malleoli with the os calcis upon either side and serve to hold the tendons passing behind the malleoli in place, so that they cannot ride forward unless the ligaments are ruptured. Separate compartments are formed behind the inner malleolus by prolongations of the internal annular ligament for each of the three tendons which lie behind the inner malleolus.

The synovial sheath for the tibialis anticus extends from 5 to 6 cm. above the ankle-joint downward to the base of the first metatarsal bone. The tendon sheaths of the peroneal tendons extend from 3 to 4 cm. above the outer malleolus downward as far as the scaphoid bone and the tendon sheath of the flexor longus digitorum extends from 3 cm. above the malleolus downward into the sole of the foot, where its sheath communicates with that of the flexor longus pollicis.

Seat of Inflammations.—From the arrangement of the bands of the anterior annular ligament, effusions into the tendon sheaths cause prominences at the points where the ligamentous structures covering them are weakest, or where they are absent. Thus, effusions into the extensor tendons produce swellings either below or above the bands of the anterior ligament. Usually the swelling occurs first below the ligament, less commonly above it. If the effusion is fluid in character, pressure below the ligament may visibly distend the sheath above the ligamentous border. Effusions into the sheath of the long extensor of the great toe usually become superficial at its lower part, at the level of the base of the first metatarsal bone, forming a somewhat sausage-shaped swelling extending up beneath the ligament upon the dorsum of the foot. Effusions into the sheath of the tibialis anticus are usually most evident at the level of the calcaneo-scaphoid joint. The tendons of the peronei possess a common sheath in the middle with prolongations upward and downward upon each tendon separately. Effusions into their tendon sheaths produce a swelling behind and above the external malleolus of an elongated, spindle shape, though

the swelling may be prolonged downward and become visible and palpable near the anterior extremity of the os calcis. In the sole of the foot the tendon of the peroneus longus receives another sheath which is, however, in close contact with the sheath above, so that inflammatory exudates readily penetrate from one compartment to the other. As stated, the tendons of the tibialis posticus, flexor longus digitorum, and flexor longus pollicis are separated from one another by fibrous septa. Effusions into these tendon sheaths are most readily appreciated behind and above the malleolus, less frequently upon the inner border of the sole of the foot, where they are covered by dense fibrous and other structures.

Inflammations of the Extensors and Peronei.—Inflammations of the tendon sheaths of the extensors and of the peronei are more frequent than similar inflammations in the sheaths of the tendons passing behind the inner malleolus. Here as elsewhere these inflammations may be of several characters. They may be simple serous or serofibrinous exudates as the result of long-continued walking or overexertion, producing the type of inflammation observed in the tendons of the dorsum of the wrist (tenosynovitis crepitans). If the exudate be dry and fibrinous, crepitation may be appreciated on palpation over the affected tendons when their muscles move them. If the exudate be serous, the tendon sheaths will be distended with serous fluid.

Gonorrheal Infection.—One of the common sites of gonorrheal infection is in the tendon sheaths of the dorsum of the foot. The inflammation is usually of a serous or serofibrinous character, very rarely purulent. The signs and symptoms are readily distinguishable. There is pain on using the affected tendons, so that the individual limps; there is tenderness on pressure, and often swelling with moderate redness of the skin along the dorsum of the foot and the front of the ankle. Such gonorrheal inflammations are not necessarily accompanied by any lesion of the joints.

The purulent infections of these tendon sheaths follow, as already stated, infected wounds and infectious diseases of the bones and soft parts of the foot. As in the palm of the hand, virulent, purulent infections tend very soon to break through the tendon sheaths and to invade the surrounding soft parts, in some cases extending upward into the leg. The conditions are readily recognized from the loss of function and pain in the region of the tendons, from the extreme local tenderness, swelling, pain, heat, and redness of the surrounding soft parts and of the accompanying symptoms of fever, leucocytosis, sepsis, etc.

Tuberculosis of the Tendon Sheaths.—Here, as in other situations, the tuberculous process may follow one of three different types. There may be a chronic serous exudate with the production of tuberculous granulation tissue in the tendon sheaths. There may be in addition the formation of rice bodies, giving similar signs and symptoms here, as elsewhere, or, in the worst cases, the fungus type of inflammation occurs, with caseation, breaking down and the formation of sinuses. The tendons most frequently in-

volved in the tuberculous process are those of the peronei, less frequently the extensor tendons and those passing behind the inner malleolus. The tuberculous infection may be primary in the tendon sheaths, or secondary to tuberculosis of the bones and joints. In the figure shown in the text (Fig. 256), in addition to the tuberculous inflammation of the extensor tendons of the foot, the patient suffered from a tuberculosis of the epididymis. Not only may the tuberculosis of the tendon sheaths be secondary to tuberculosis of bones and joints, but in the caseating form tuberculosis primary in the tendon sheaths may secondarily involve the deeper structures. When the peroneal tendons are secondarily involved the primary focus is more often found in the os calcis than elsewhere.

FIG. 256.—TUBERCULOUS TENOSYNOVITIS OF THE EXTENSOR TENDON OF THE GREAT TOE. Tuberculosis of the epididymis. (New York Hospital collection, service of Dr. Frank Hartley.)

THE DISEASES OF THE BURSÆ OF THE FOOT

The bursæ, constant and inconstant, in the region of the foot are very numerous. The most common ones are shown in Figs. 243 and 244 from Merkel. Among the most constant of these bursæ is one which lies between the tendo Achillis and the tuberosities of the os calcis. This bursa is one of those most frequently inflamed. The inflammation may result from trauma, as from overexertion, or from a blow or fall upon the heel, or it may become inflamed in the course of a variety of infectious diseases, notably *gonorrhea*. The bursa may also become inflamed and suppurate as the result of infected wounds. The symptoms of inflammation of this bursa are pain on walking, localized pain, and tenderness upon either side of the tendo Achillis just above the os calcis, and if the exudate be considerable a fullness in the same situation with tenderness on pressure. An irritative periostitis may be associated with gonorrhea of the bursa and may produce a spur of new bone on the os calcis demonstrable by the X-rays.

The diagnosis of the causation of a bursitis in this situation must depend upon the history of injury, the presence or absence of gonorrhea, or other infectious process, or, on the other hand, upon the existence of an infected wound. It is necessary in some cases to eliminate disease of the os calcis.

This can sometimes be done by means of the X-rays, and in other cases aspiration of the bursa, or incision thereof, and exploration of its cavity will serve to demonstrate or to eliminate the presence of disease in the bone itself. A bursa sometimes occurs upon the inferior surface of the os calcis, and this may also become inflamed as the result of injury or of gonorrhea, etc. A bursa also occurs in a certain proportion of cases behind the tendo Achillis between it and the deep fascia. This occasionally becomes inflamed and gives rise to localized pain and tenderness, but does not interfere to the same extent with the function of walking as does the bursa situated in front of the tendon.

Simple ganglion is a condition but rarely observed in connection with the tendons or tendon sheaths of the foot, the condition being far less frequent here than upon the hand. The diagnosis is to be made from the presence of a rounded, tense, fluctuating, elastic tumor over one of the joints, or connected with the sheath of a tendon.

NECROSIS OF THE TISSUES OF THE FOOT

In the chapter on Gangrene in Vol. I, most of the forms of massive tissue necrosis have been sufficiently described, and the reader is referred to this section for the consideration of gangrene in general. Two other conditions which occur in the foot, however, deserve some further attention. They are erythromelalgia and presenile gangrene (intermittent claudication). Here it may be said that Raynaud's disease is believed to be chiefly, if not exclusively, due to an affection of the nerves presiding over the muscular walls of the blood-vessels, and that in this disease a spasm of the blood-vessels occurs of a peculiar character, resulting in gangrene of the toes, the fingers, the nose, the ears, without any necessary complicating arteriosclerosis. In some of the cases arteriosclerosis is, however, present, yet pathological examination would indicate that in the majority of instances degeneration of the blood-vessels is absent. Personally, I should be inclined to separate Raynaud's disease en-

Fig. 257.—Dry Aseptic Gangrene of the Foot, Due to Obstruction of the Femoral Artery and Vein. (New York Hospital collection, service of Dr. Frank Hartley.)

tirely from the cases of presenile gangrene to be described in a later section, in which the causative lesion is unquestionably a narrowing and more or less complete obliteration of the peripheral vessels. Still another condition deserves notice in this connection—namely, syringomyelia. We have already described in the sections on the upper extremity the lesions of syringomyelia (Morvan's disease). The trophic disturbances as there described are much more frequent in the upper than in the lower extremity. Nevertheless, in rare instances, such disturbances do occur in the latter situation. It is to be borne in mind, however, that the disturbances of sensation and motion in syringomyelia are usually so characteristic that no confusion between this disease and the other forms of neurotic and trophic disturbances of the extremities should arise. The following table, quoted by Cassirer and modified from that of Castellino and Cardi, also quoted by Osler,[1] will serve to point out the differential data between syringomyelia and Raynaud's disease:

Syringomyelia	Raynaud's Disease
1. Begins gradually.	1. Begins suddenly.
2. Course very chronic; ten to fifteen years.	2. Course more acute; one to three months.
3. Begins usually in one extremity and extends slowly to the others.	3. Symmetrical onset the rule.
4. No previous vasomotor changes.	4. Vasomotor changes marked.
5. Recurring painful panaris.	5. Dry gangrene.
6. Skin cyanotic and cold.	6. Skin black and cold.
7. Dissociation of sensation.	7. Anesthesia or paresthesia.
8. Atrophy of muscles.	8. Atrophy very rare.
9. Ulceration common.	9. Ulceration rare.
10. Nails lost, and when reformed much curved and thick.	10. Nails dark, not deformed.
11. Necrosis and separation of bone.	11. } Atrophy of terminal phalanges
12. Fingers much curved and contracted.	12 } only.

Erythromelalgia

(Weir Mitchell's Disease)

History.—In 1872 Weir Mitchell described (*Philadelphia Medical Times*) "a rare vasomotor neurosis of the extremities." In 1878, in the *American Journal of the Medical Sciences*, he published another paper upon the same topic, and again in the same journal in 1899, and in the *Medical News* of 1893 he named the condition *erythromelalgia*, signifying a painful, red state of the limb. For an elaborate monograph upon the topic and for the bibliography, see the monograph by Cassirer, "Die Vasomotorisch-trophischen Neurosen," Berlin, 1901.

[1] Osler's "Modern Medicine," vol. vi, p. 642.

Causation.—Erythromelalgia is a very rare disease. Osler [1] states that in the Johns Hopkins Hospital, during twenty years up to 1909, but three cases were observed. The disease is more common among men than among women. Cassirer's report as to its occurrence during different periods of life is as follows: From the age of one to ten years, 2 cases; from the age of eleven to twenty, 2 cases; from twenty-one to thirty, 21 cases; from thirty-one to forty, 13 cases; from forty-one to fifty, 11 cases; from fifty-one to sixty, 12 cases; from sixty to seventy, 2 cases; over seventy, 2 cases.

Although the etiology of the condition is quite obscure, some of the observed cases have followed infectious diseases, such as gonorrhea, syphilis, and rheumatic fever. Exposure to cold and wet are believed to be important exciting causes, and in a number of instances there has been a well-marked history of such an exposure. Overexertion of the lower extremities has also been followed by an attack.

Pathology.—Cassirer divided the cases into two groups. One in which the symptoms are localized in some definite area of nerve distribution, the other in which the lesions are distributed over the distal segment of the limb without reference to nerve distribution. In the first group of cases the symptoms of peripheral neuritis may be present, or, on the other hand, such symptoms may be entirely absent. In the second group no evidence exists indicating a lesion of the blood-vessels, nerves, spinal cord, or brain. In other words, the pathology of the condition is quite obscure; although in a certain proportion of the cases studied postmortem, changes in the nerves and blood-vessels have been observed, they are inconstant. Cassirer considers that in the cases with lesions corresponding to nerve distribution a peripheral neuritis is probably present. On the other hand, when the entire limb is involved, he considers that the disturbance is one of the vasomotor centers. Thus, when we come to compare the disease with the symmetrical gangrene of Raynaud, we find that the symptoms of the two conditions much resemble one another, except that in erythromelalgia, as described by Mitchell, Cassirer, and others, gangrene does not occur. Further, it is to be borne in mind that many of the cases of presenile gangrene exhibit symptoms almost identical with erythromelalgia during their earlier stages, but that in the former group of cases more or less extensive gangrene follows, while in the latter it is absent. Further, in the typical cases of erythromelalgia, the arteries of the extremity show an increased pulsation and the arterial circulation of the part is in excess of the normal, while in presenile gangrene, though the toes and foot may be intensely congested, the circulation of the part is sluggish and arterial pulsation in the dorsalis pedis and posterior tibial arteries is diminished or absent.

Symptoms.—The symptoms of pure cases of erythromelalgia are as follows: After some exciting cause, exposure to cold and wet, overfatigue, or some other similar accident, possibly after prolonged and undue nervous strain, an indi-

[1] Osler, *loc. cit.*, p. 676.

vidual, most commonly a young person usually otherwise in fairly good health, begins to suffer from pain, redness, and swelling of one foot or of the foot and leg. The pain is rendered worse by walking and by the upright position, and diminishes or disappears when the patient lies down with the foot elevated. After exercise, examination will show that the foot and a portion of the leg is swollen, intensely red, and extremely painful. The redness is usually of a bright and vivid character, though the toes are often bluish or light purple in color. There is usually no edema, nor is there any marked tenderness in the course of the peripheral nerve trunks. The pulsation of the arteries of the foot and ankle is increased rather than diminished. There may be fairly marked tenderness over one or more toes or in the sole of the foot. The recumbent posture causes immediate diminution or almost complete subsidence of the symptoms, the redness, pain, and the swelling rapidly diminish and may entirely disappear, or in other cases the toes or a portion of the foot remain somewhat red and congested, unless the recumbent posture is maintained for hours.

While the disease is most frequent in the foot, one or both feet being involved, the hands may also be affected, or in certain instances all four extremities. In a certain proportion of the cases the pain, heat, redness, and swelling may be limited to the distribution of a single nerve trunk. When the feet are affected, the disease may begin in one or more of the toes and gradually spread to the entire foot and to the lower part of the leg. The local signs seldom extend above the knee or the elbow, respectively.

The most characteristic symptom of the disease is the *redness*. It is not the redness of an acute inflammatory lesion, nor yet of venous congestion, but an intense hyperemia of the vessels of the part producing a uniform or more or less diffuse pink or vivid red color of the skin, often with a sharply marked boundary at its upper limit. In addition to the redness, the limb feels subjectively and objectively warmer than the rest of the body, and such an increase in temperature is commonly appreciable with a surface thermometer by comparing the surface temperature of some indifferent part of the body with the red area. The elevation may amount to 5° or 6° F. or more. One of the most marked characters of the condition, as already indicated, is that the symptoms are most severe when the limb is used in walking, or when it hangs dependent, and rapidly diminish in intensity as soon as the patient lies down and elevates the foot. *Pain* of a burning, throbbing character is complained of, which may be limited to some particular nerve distribution, or be diffuse and referred to the entire affected portion of the extremity. The pain again is rendered worse by a dependent position of the limb or by walking, and rapidly diminishes when the patient lies recumbent. In some cases the pain is of a sharp and stabbing character. *Tenderness* on pressure may also be marked over the swollen and reddened areas, and such tenderness may be extreme. Although the part is distinctly swollen, there is usually no pitting on pressure, such as accompanies edematous and inflammatory lesions. The dis-

turbances of sensation are usually confined to pain and more or less hyperesthesia. From want of use the muscles of the limb may undergo a partial atrophy.

Differential Diagnosis.—The differential diagnosis is not in all cases easy. I have seen a number of instances in which the symptoms as above described existed, with the exception that there was no increased arterial pulsation in the limb, which were in the end followed by gangrene involving one or more toes or a large portion of the foot. Indeed, it is probably impossible in a good many instances, unless the patient is kept under prolonged observation, to differentiate erythromelalgia from some of the cases of presenile gangrene and from Raynaud's disease. In fact, the early symptoms of the hyperemic stage of Raynaud's disease are practically identical with erythromelalgia. The following is the differential table of Weir Mitchell:

Raynaud's Disease	Erythromelalgia
1. Sex, four fifths females.	1. In 22 cases 2 were women.
2. Begins with ischemia.	2. Little or no difference in color is seen until the foot hangs down in upright position, when it becomes rose-red.
3. Affected part becomes bloodless and white. In certain cases there is a deep, dusky congestion of a cyanosed part with or without gangrene.	3. The arteries throb and the color becomes dusky red or violaceous in tint.
4. Pain may be absent or acute, and comes and goes; has no relation to posture; may precede local asphyxia.	4. Pain usually present; worse when the part hangs down or is pressed upon. In bad cases more or less at all times.
5. Unaffected by seasons. In many cases all the symptoms are brought on by cold.	5. Worse in summer, and made worse by heat; eased by cold.
6. Anesthesia to touch.	6. Sensations of all kinds preserved.
7. Analgesia.	7. Hyperalgesia.
8. Temperature much lowered and unaltered by position.	8. Temperature above normal. Dependency causes in some instances an increase, in others, a lowering of the temperature.
9. Gangrene local and limited, and likely to be symmetrical.	9. No gangrene; lesion asymmetrical.

The typical cases of erythromelalgia, although they do not eventuate in gangrene, are stubbornly resistant to all forms of treatment. Prolonged rest in bed, hydrotherapy, massage, electricity, and other measures may all be tried, but of them all the rest in bed is probably the most important.

Presenile Gangrene

(Localized Endarteritis Obliterans, Friedländer's Disease, Intermittent Claudication)

Presenile gangrene of one or both extremities as seen in the City of New York is not a very rare disease. Within the past four years six cases requiring

amputation, either of the leg or thigh, have come under my observation, and in three of them the disease was bilateral. The patients have all been men Hebrews. The average age of these individuals has been about thirty-five years. In no case was a history of syphilis obtainable, and in no case were the individuals chronic alcoholics, nor was there anything in their modes of life or in their histories to account for the arterial degeneration. I am informed that in the Mt. Sinai Hospital a very considerable number of these cases are treated every year.

Signs and Symptoms.—The signs and symptoms in the cases which I have had under observation have been quite typical. The individuals observed that they suffered pain in the calf of the leg, in the toes, and in the feet while walking, and in the course of months or years the pain became so severe that they were obliged to sit down and rest after walking only a block or two. They also noticed that one or several, or all the toes of one foot became red or reddish-blue, swollen and congested when using the limb. In some cases the swelling and redness has been confined to the toe or toes, in others it has advanced upward a variable distance upon the dorsum of the foot, even as far as the ankle. The limit of the redness has been usually sharply marked above. After the disease had existed for several years, there was formed in some cases a small ulcer upon one or more of the toes. This ulcer became covered with a black scab, was excruciatingly painful, so that the individuals were more or less constantly confined to bed, or were obliged to sit with the foot elevated.

The most typical character of the disease is that the symptoms are greatly increased in severity when the patient walks upon the limb or permits it to hang in a dependent position, and almost completely subside in the majority of instances after rest in bed. In some cases the pain has only been complained of when the patient walked or used the limb; in others the pain has been diminished by the recumbent posture, but has not disappeared. In two of the cases under my observation the pain was rendered worse by the use of the limb, but did not disappear, even though the recumbent posture was maintained for days or weeks. In these cases there was severe neuralgic pain complained of at night and referred to the distribution of the nerve trunks supplying the foot and toes. In all the cases observed, there has been absence of pulsation in the dorsalis pedis and posterior tibial vessels. In several the popliteal artery could not be felt, and usually the pulsation of the femoral in Scarpa's triangle was notably less marked upon the affected side.

The *progress* of the disease in all the cases has been extremely slow, and in no instance coming under my observation had the symptoms existed for less than two or more years. In one, a young man of thirty-two years of age, all ten toes were either gangrenous or had upon them gangrenous spots. This young man was entirely unable to use his limbs, and he suffered the most excruciating pain upon making the attempt to walk. He had had every variety of local treatment without benefit. It was very hard to advise him to have

an amputation of both feet, and yet the experience of all observers of this disease is unanimous that in these cases nothing short of amputation is of benefit.

Prolonged rest in bed and careful stimulating treatment of the ulcerated or gangrenous areas upon the toes and foot will sometimes result in healing of the lesions, but immediately upon the resumption of the erect attitude and the use of the limb the healed ulcers quickly break down and either become gangrenous or persist indefinitely as sluggish, slowly destructive processes.

In all six of these cases I did an amputation; in four of them I amputated through the middle third of the leg, making incisions in the skin and muscles at various levels from below upward, until I found a level at which the vessels bled more or less freely. In one case I was obliged to amputate through the lower third of the thigh, since incisions in the calf were followed by such trifling bleeding that I did not dare to amputate below the knee-joint. In this case primary union occurred in the wound, the patient was relieved from his pain. He has now, however, disappeared from observation, and I do not know what was his subsequent fate. In another case I amputated through the middle of the leg. Primary union occurred in the wound. Two years later the patient returned with a superficial ulcer upon the stump. In the meantime he had worn an artificial limb with comparative comfort. He returned to have the ulcer treated. It was excised, apparently with a good result, but at the present time the disease has appeared in the other foot. I have not the heart at present to recommend another amputation. In still another case the gangrenous lesion was confined to the great toe. The patient refused amputation of the leg and I amputated his great toe. Primary union occurred in the wound and he returned to his home in Brooklyn, having promised that he would keep me informed as to his subsequent history. This happened four years ago and I have not heard from him since.

In the experience of others in the New York Hospital, I have seen a number of these cases in which amputation of one or several toes was made, and in all of them the patients returned, sooner or later, with gangrene of other toes. These were amputated, but I think that in every instance amputation of the leg or thigh was finally resorted to. The pathological examination of the amputated limbs showed in every instance obliterating endarteritis extending upward to the point of amputation. The lumena of the dorsalis pedis and posterior tibial arteries were in every instance very greatly diminished.

In several of the cases the changes of a chronic neuritis were observed in the nerve trunks of the amputated part.

Differential Diagnosis.—The differential diagnosis between this form of presenile gangrene, Raynaud's disease, and erythromelalgia must be made from the fact that in this group of cases the symptoms of pain, heat, redness, and congestion of the toes or foot are accompanied by very evident diminution in the size of the arteries of the extremity; that the disease is essentially very chronic and slowly progressive though it is not necessarily symmetrical; that

the patients are almost invariably Hebrews, and that the characteristic int mittent occurrence of the symptoms is quite different in the typical cases true Raynaud's disease.

DISEASES OF THE JOINTS AND OF THE BONES OF THE FOOT

The joints of the foot and ankle are subject to the same acute and chro inflammatory lesions as other joints. Such may, as elsewhere stated, be du open wounds or to infectious processes in the vicinity which invade the joi or to the greatest variety of constitutional infectious processes, already el where enumerated many times in this book; nor do inflammations of thes joints possess any very marked peculiarities which distinguish them from similar lesions in other joints. A few remarks, however, may here be made in regard to their especial characters.

Acute Inflammations

Effusions into the ankle-joint present superficially over those portions of the capsule of the joint which are covered by the least dense surrounding soft structures. On the front of the joint to either side of the bundle of extensor tendons, such exudates usually first make themselves manifest as superficial swellings. Such swelling, however, may well be obscured by inflammatory edema or infiltration of the subcutaneous tissues and the skin. If the effusion becomes very great indeed, the bulging joint capsule may become palpable behind and below either malleolus. Here again the commonly associated swelling and edema of the soft parts will render palpation of the joint capsule and recognition of the exudate difficult or impossible. There is no very characteristic position which the ankle-joint assumes on account of extreme intra-articular tension, but the weight of the foot usually tends to bring the ankle-joint, as the patient lies recumbent, into a position of moderate plantar flexion. The presence of inflammation of the ankle-joint may, however, be recognized by spontaneous pain, loss of function, and pain on passive motion. If the disease has existed for some little time and the inflammatory process is severe, the joint may be quite immobile, or if moved the motion will give rise to intense pain. If the cartilages are eroded or destroyed, there may be felt a rough, fibrous sensation of friction as the joint surfaces are moved one upon the other, or if the cartilages are gone and the bone is exposed there may be even bony grating. The character of the exudate here as elsewhere may be inferred from the origin of the process in many instances—namely, if the inflammation is due to a subcutaneous injury, a fracture, a dislocation, or the like, it may be assumed that the exudate is serous or consists of serum mixed with blood. If due to an infected open wound, the exudate is probably purulent. If, on the other hand, the inflammation is the result of a generalized infectious disease, the character of the exudate may often be inferred from the fact that, as the result of experience, the different infectious or septic

processes are likely to be attended by a joint exudate of a serous, sero-purulent, or purulent character, respectively.

The use of the aspirating needle, together with cultures of the aspirated material, will often afford valuable aid in the diagnosis. The local signs of inflammation, pain, heat, redness, and swelling, the general symptoms of sepsis, often permit a probable conclusion as to the nature of the process in the joint itself. Of all the joints in the body the ankle-joint is one of the most difficult to drain successfully when it becomes the seat of pyogenic infection. The contour of the joint surfaces is so irregular that no single opening into the joint will suffice. Posteriorly, the borders of the malleoli fit so closely to the astragalus that the space for drainage is very small. On the front of the joint the conditions are but little more favorable.

An important point to bear in mind when treating any inflammatory lesion of the ankle-joint, whether incision and drainage be necessary or not, is that we can never be sure that the process will not be followed by stiffness of the joint or complete ankylosis, and therefore we should maintain a position midway between plantar flexion and extension—namely, the foot at right angles to the leg and neither supinated nor pronated, so that, if ankylosis does occur, the patient may still be able to walk with comfort upon his foot. If suppuration of the joint is due to osteomyelitis of the os calcis, or of the astragalus, or of the tibia or fibula, it is to be borne in mind that here the conditions for drainage may be somewhat more favorable after the portion of infected bone is removed. It is also to be borne in mind that the functional result after the removal of the astragalus is often extremely good, and that removal of the astragalus affords very perfect drainage indeed for the ankle. Removal of one or other of the malleoli, on the other hand, is attended by profound disturbance of function in the ankle-joint, and under such conditions ankylosis is probably the most favorable result obtainable.

In regard to infectious processes of the smaller joints of the tarsus, it is to be borne in mind that many of the joints communicate freely one with the other, and that those which do not so communicate lie so close together and are separated by such feeble barriers that suppurative processes readily advance from one joint to the other until many joints are invaded. Such infectious processes may, however, sometimes be successfully combated by removal of one or more of the tarsal bones. In the operative approach to the joints of the tarsus for purposes of drainage, it is to be borne in mind that the dorsum of the foot or to the one or other side thereof affords the only practicable avenue of approach. The tissues of the sole are so thick and so dense that it is useless to approach these joints from below. It is to be remembered in the treatment of *acute suppurative* inflammations of the smaller joints of the tarsus that simple incision and drainage is rarely sufficient to effect a cure. As a general rule, to which there will be but few exceptions, it will be necessary to remove one or more of the smaller bones entering into the joints in order to secure proper drainage. This method of treatment will be successful

in a certain proportion of cases. In others, the disease will advance from one joint to another and from one bone to another, necessitating finally an extensive operation, or even amputation.

The following brief histories of two cases of infected wounds in the vicinity of the ankle will serve to illustrate the favorable results possible in infected wounds of the smaller joints of the tarsus, and, on the other hand, the possible disasters as the result of improper treatment.

The first case was a boy aged about twelve.[1] While climbing about a manger in a stable he slipped and fell against a protruding wire nail, which punctured his right ankle, entering the joint between the astragalus and scaphoid bones. The child was seen by a doctor, who did not consider the injury serious and applied some simple dressing to the wound. After a few days, however, the foot became very painful and the ankle swollen; the child was no longer able to walk on the limb. He developed fever and felt ill. Five or six days after the injury he was brought to the city and came under my care. At this time the portion of the ankle and foot near the wound was swollen, red, and very tender; all motions of the foot were painful. There was a minute punctured wound upon the side of the foot over the astragalo-scaphoid joint, from which some drops of pus could be extruded by pressure. The boy had moderate fever, prostration, and leucocytosis.

Under ether anesthesia I exposed the joint through an incision, and found that the nail had entered it, creating a small puncture; the joint contained thin pus. The joint cavity was washed out with a weak solution of carbolic acid and drained through a small rubber tube. The discharge from the joint continued to be purulent, and the character of the pus showed evidences of an infection rather increasing than diminishing in severity. Cultures made from the exudate showed the presence of the yellow staphylococcus. At the end of about a week the local condition not being improved, I removed the scaphoid bone and dissected out the synovial membrane of the joint. Rapid improvement followed. The wound healed and the functional result was good.

A second case now under my care in the New York Hospital is a little boy, aged seven, who ran a nail into the inner aspect of his right ankle just below and a little in front of the internal malleolus. He received treatment at the hands of a doctor, who applied a poultice to the wound. I saw the child some ten days after the accident. He was profoundly septic, his mental condition was dull and apathetic, he could scarcely be induced to swallow liquid food. The inner aspect of the ankle was occupied by a sloughing raw surface an inch broad and an inch long. From this surface creamy pus exuded when the foot or the lower third of the calf of the leg was compressed. Incisions showed that the intermuscular planes of the lower third of the calf were filled with pus. The subcutaneous tissues of the sole from the heel to the middle of the foot were infiltrated with pus. The calcaneo-astragaloid joints were disintegrated. As the result of free incisions and energetic disinfection the condition of the

[1] Case mentioned on page 608.

child had improved notably at the end of forty-eight hours, and it is now hoped that his life, and perhaps even his leg, may be saved.[1]

The bones of the tarsus and metatarsus occasionally become the seat of an *acute suppurative osteomyelitis.* The infection may take place through a wound or through the blood. The lesions may have multiple localizations or be confined to the foot. No special rules for diagnosis as to the nature of the condition or as to its anatomical site can be given. The signs and symptoms are here as elsewhere those of more or less marked sepsis, together with the local signs of a severe suppurative process. (See Osteomyelitis.) Of the bones of the tarsus, the os calcis is most frequently the seat of osteomyelitis. Here as elsewhere, the process may be part of a general septicemia, or may follow open wounds or infectious processes of the soft parts of the foot or joints.

The conditions in the os CALCIS for evacuation of the pyogenic focus and removal of the infected bone, without involvement of the neighboring joints and without serious loss of function, are better than in the other tarsal bones. The diagnosis is to be made from the local signs and symptoms of an acute pyogenic infection. The region of the heel becomes swollen, there is tenderness below the malleoli over the os calcis and the other local signs of an acute pyogenic infection. If seen first after spontaneous rupture of the abscess has occurred externally, there will be the history of a former acute illness and the presence of a sinus leading to dead bone. In these cases the extent of the inflammatory process and the size of the sequestra may sometimes be determined by means of an X-ray picture.

The other tarsal bones are less frequently the seat of acute osteomyelitis due to general causes than is the os calcis. When they become the seat of acute pyogenic infection, it is more often due to infected wounds or to localized inflammatory processes of the surrounding soft parts and joints.

THE METATARSAL BONES are rather more frequently the seat of acute osteomyelitis whether due to traumatisms or acute local infections. The signs and symptoms resemble those of osteomyelitis elsewhere. When due to general septic infection the disease of the metatarsal bones is usually associated with osteomyelitis in other long bones—tibia, femur, humerus, etc. When, as rarely happens, the metatarsal bones are alone the seat of the infectious process, the disease will be quite often mistaken in its early stages for a suppurative lesion of the soft parts, or in the absence of a carefully conducted examination of the blood, etc., such infections may be confounded with acute rheumatic fever with so-called gonorrheal rheumatism, or even with gout. The exact diagnosis is best made by direct inspection of the parts through an incision.

CHRONIC INFLAMMATIONS

A great variety of chronic inflammations may occur in the bones and joints of the foot. Many of them do not require a separate description, since their

[1] The foot was saved in this case.

signs and symptoms do not materially differ from similar lesions in other parts elsewhere fully dwelt upon. There may be mentioned acute articular rheumatism of the joints of the foot and ankle, and here the diagnosis will depend upon the data given elsewhere. The ankle-joint and the joints of the tarsus and metatarsus are one of the favorite localizations for gonorrheal arthritis, and here as elsewhere these inflammations show a strong tendency toward relapses and toward the production of fibrous ankylosis. Great attention should, therefore, be paid to the position of the foot during the treatment.

Arthritis Deformans.—The ankle-joint and the joints of the tarsus are one of the rarer localizations of arthritis deformans, and the disease scarcely ever occurs in these situations without associated lesions in one or other of the larger joints—the hip, the knee, etc. Arthritis deformans as the result of *trauma*, however, is by no means rare in the ankle-joint. It may follow one or other of the fractures of the bones of the leg close to or involving the ankle-joint, and perhaps more frequently than any other fracture the condition follows *imperfectly reduced* fractures of the malleoli with abduction of the foot. I have seen a number of cases of this kind in which the resulting disability and pain, together with the production of a synovial pannus, the formation of osteophytes, and destruction of the articular cartilages, constituted a lesion so severe that from pain and deformity the individuals were almost completely incapacitated. Some of these cases can be relieved by an osteotomy of the bones of the leg, such that the line of support is brought more nearly into a normal relation with the articular surface. In some cases, osteotomies at the seats of fracture and forcible overcorrection of the deformity is followed by good functional results. In other cases fairly good results may follow erasion of the ankle-joint with the production of ankylosis. In still others removal of the astragalus may be indicated, and in some the lesion is so extensive and the deformity so great that nothing short of amputation promises a favorable result. The progress of arthritis deformans of the ankle-joint resembles that of similar lesions in other joints. See section on Chronic Disturbances of Joints in this volume.

The *diagnosis* is to be made from the history of an injury or of a very chronic joint disturbance, with peri-articular thickening, diminution of motion, intra-articular grating, the presence of osteophytes, etc. The changes in the shape of the bone, sometimes the destruction of the cartilages, may be well shown by means of X-ray pictures. Arthritis deformans affecting the metatarso-phalangeal joints and the interphalangeal joints of the toes is not very rare in elderly persons, the subjects of arthritis deformans in other joints, and usually the condition presents no difficulties in diagnosis. The deformities produced in the toes are not unlike those produced in the hand. (See Fig. 39, page 171, Vol. I; also Fig. 38, page 170, Vol. I.)

Arthritis deformans of traumatic origin is one of the lesions of *hallux valgus*, to be described in another section.

Gout.—The metatarso-phalangeal joint of the great toe is one of the favorite localizations of gout. The disease is hardly to be regarded as surgical, and a very brief description of it alone will be necessary here. An attack of gout is characterized by a sudden, violent inflammation involving the metatarso-phalangeal joint, with acute inflammatory infiltration, swelling and edema of the surrounding structures and excruciating pain.

In gout, during acute attacks, there is a marked increase of uric acid in the blood. The changes in the excretion of uric acid in the urine are thus formulated by Minkowski:

(1) The daily excretion of uric acid, in the intervals between acute attacks, ranges within the same limits as does the excretion in healthy individuals. (2) In chronic gout, even in those cases in which there is marked deposition of biurates in the tissues, a constant diminution in excretion of the uric acid has not been definitely proved. (3) Immediately preceding an attack there is regularly a diminution in the amount of uric acid eliminated in the urine, whereas, during and after the attack, the uric acid output is increased.

The amount of uric acid eliminated in twenty-four hours in the urine of a healthy adult individual upon ordinary diet varies between 0.4 and 1 gm. According to Minkowski the ratio of uric acid to urea ranges in health from between 1 to 50 to 1 to 70, and, according to the same author, the ratio of uric-acid nitrogen to total nitrogen varies between 1 to 20 and 1 to 120. The form in which uric acid is eliminated in the urine is not exactly known, but it is evidently in loose combination with some other organic substance, so that the uric acid is readily set free. There is in gout a very marked disturbance of nitrogen metabolism.

One of the tests for the presence of an excess of uric acid in the blood is that of Garrod. It may thus be carried out. Blood serum is obtained either by producing one of the artificial forms of a blister and aspiration of its contained fluid, or by separating the corpuscles from the serum after it has been withdrawn from the body.

To two drams of the serum, in a rather flat watch crystal, add six minims of moderately strong acetic acid for each fluid dram used. Mix well, and introduce one or two ultimate fibers from a linen thread or from a piece of unwashed linen fabric. Set aside in a cool place for from thirty-six to sixty hours until the serum is quite set and almost dry. If uric acid be present in excess (equal to at least 0.025 grains of uric acid in 1,000 grains of serum in addition to the trace existing in health) it will crystallize out on the fibers, and, under the microscope, will resemble the appearance of sugar candy on a string.[1]

An attack of gout localized in the metatarso-phalangeal joint may be described as follows: An individual, usually an otherwise healthy man of middle age, is awakened in the night by an intense pain in one or other of the metatarso-

[1] T. B. Futcher, Osler's "Modern Medicine," vol. i, p. 825.

phalangeal joints. After some hours there is a moderate elevation of temperature, 100° to 103° F., and the joint is found to be swollen, red, tender, and exquisitely painful upon passive motion or palpation. The spontaneous pain is often very severe. The symptoms are apt to diminish in intensity during the day, to be renewed the following night with violent pain, which is referred to the entire foot, but is most marked in the affected joint. The constitutional symptoms usually begin to subside in the course of from forty-eight to seventy-two hours, although the local lesion is apt to increase in severity for a number of days. The affected joint is greatly swollen, the overlying skin is red, tense, and shiny. Suppuration does not occur. There is often a moderate leucocytosis. Such attacks may be renewed at intervals, either spontaneously or as the result of excess in eating or drinking. It is generally asserted that sweet and rich wines, notably champagnes and burgundies, predispose to or excite attacks. The intervals at which the attacks occur are entirely irregular. Subsequent attacks may follow in a month, in a few months, or not for many years. In some cases the acute joint inflammation is preceded by some disturbance of the general health, loss of appetite, irritability, insomnia, and depression of spirits. When a number of attacks occur, there is usually deposited in the peri-articular structures a greater or less quantity of urates, constituting the so-called gouty tophi. These gouty deposits may be found not only in the vicinity of the affected toe-joints, but in other situations—in the ears, in the fingers, upon the elbows, in the cartilages of the nose, in the sclerotic of the eye, and in the eyelids.

In chronic cases there may be roughening of the cartilages and creaking on motion. The duration of an acute attack of gout varies from four or five days to a week or more. As a rule, the diagnosis of an acute attack offers no difficulties. In the chronic cases, however, notably in those cases in which gouty tophi are not evident, the disease may be confounded with arthritis deformans. In cases of doubt, careful inspection of the cartilages of the external ear should be made, since here gouty deposits are more often found than elsewhere, and if such a gouty tophus be removed, the microscopic contents of the little sac will show characteristic needle-shaped crystals of sodium biurate. It is to be borne in mind that unlike acute articular rheumatism, an acute attack of gout may occur without fever, and in the absence of any other probable cause the occurrence of an acute attack of inflammation, notably in the metatarso-phalangeal joints, renders the diagnosis of gout almost certain.

Syphilitic Inflammation

The several forms of syphilitic inflammation of joints occur in the ankle and in the joints of the foot, but are rather unusual localizations of the disease. The late lesions of the joints present the same characters here as elsewhere—namely, a partly destructive and partly productive inflammation of the bones and of the soft parts surrounding the joint.

The lower epiphysis of the tibia may be involved in the pseudoparalysis of Parrot. (See Vol. I, Syphilis.)

Syphilis of joints has been sufficiently described in other sections of this book, to which the reader is referred.

In the metatarsal bones a syphilitic osteoperiosteitis occurs, as in the fingers and hand. These lesions are more common in hereditary than in acquired syphilis, and produce a fusiform enlargement of the bone, a typical syphilitic *spina ventosa*. The end result in these cases may be that, under treatment, the products of the syphilitic inflammation are reabsorbed with *restitutio ad integrum*, or in other cases the bone infiltrated with gummatous material breaks down and undergoes a more or less extensive syphilitic necrosis, with the formation of sinuses. In children the differential diagnosis between syphilitic and tuberculous inflammations of the metatarsal bones may be quite difficult, and in these cases resort must often be had in the absence of a definite syphilitic history, or of other characteristic syphilitic manifestations, to one or other of the tests, the Wassermann reaction, search for the spirocheta pallida in the exudate or in the tissues, and the use of one or other of the tuberculin tests. It is to be borne in mind that syphilis and tuberculosis may coexist in the same individual.

Usually a syphilitic dactylitis originates in the bone or periosteum. In rarer instances the syphilitic process may begin in the soft parts and subsequently involve the bone. The syphilitic inflammations of these small bones are usually not particularly painful, and in this they again closely resemble tuberculosis. In adults, syphilitic inflammations of the bones of the foot are usually more readily recognized as such than is the case with infants. In adults there will usually be a history of syphilitic infection and of antecedent manifestations, together with the presence of syphilitic scars, etc. In the cases where the gummatous material undergoes softening and the bone becomes necrotic, considerable sequestra may be formed and their spontaneous or operative removal will be followed by a greater or less loss of substance in the bone, and if the continuity of the first metatarsal bone be destroyed fairly marked deformity and disability may follow.

In cases of late congenital syphilis, the bones of the foot may occasionally be affected. The differential diagnosis must be made from tuberculosis. These cases of late hereditary syphilis, however, present a fairly characteristic general picture of a constitutional dyscrasia. The patients are undersized, delicately built, and poorly developed. They are usually pale and anemic. There may be present the typical beveled notches upon the cutting edges of the incisor teeth, the so-called *Hutchinson's teeth*, *interstitial keratitis*, or the evidences of its former presence upon the cornea are often observed. *Deafness* from successive attacks of inflammation of the middle ear is a very common lesion in late hereditary syphilis. The bones of the skull are often irregularly developed. The root of the nose is sunken, the tip of the nose turns up and is prominent. The skull is often of irregular shape and there is frequently an

abnormal prominence of the bones in the frontal region. Syphilitic thickenings of the skull, in the form of small elevated bosses, are sometimes observed; and scars upon the skin and at the corners of the mouth, the results of former syphilitic eruptions, are common. These patients usually exhibit an imperfect cerebral development. The genital organs often remain imperfectly developed and the hair and the beard, if the patient be a male, are scanty. The bodies of such young persons are often nearly hairless.

Tuberculous Inflammations

Tuberculosis of the joints of the foot is usually primary in the bones, more rarely in the synovial membranes. The astragalus, the os calcis, the tibia, the cuneiform bones, the metatarsal bones, the cuboid bone, the scaphoid, and the fibula are affected in the above order of frequency, or nearly so. In a fairly large proportion of cases several bones are involved. Tuberculosis of the ankle-joint itself more often arises from a focus of tuberculosis in the astragalus, which subsequently invades the ankle-joint, than from any other situation. Next in frequency, or perhaps of nearly equal frequency, the primary lesion exists in the os calcis. The following statistics in 71 cases in the clinic of Ollier indicates that the astragalus is the most frequent seat of the tuberculous focus. Thus, he found the primary focus in the astragalus 22 times, in the os calcis 13 times, in the scaphoid bone 3 times, in the cuboid bone once, in the lower end of the tibia 9 times. In 23 cases the disease appeared to be primary in the synovial membrane. The statistics of Riedel would seem to indicate that the disease was primary in the synovial membrane in about one third of his cases.

The early symptoms of tuberculosis of the *ankle-joint* consist of pain in the joint on motion, with limitation of passive and active movement, the production of a limp, and the gradual formation of a swelling including the ankle and upper part of the foot. Upon inspection, the joint is swollen more or less symmetrically, although the most prominent part of the swelling is usually in front of the joint. When the disease is further advanced the swelling on the posterior aspect of the joint produces a considerable broadening of the heel. The bony prominences of the malleoli are lost in the swelling and a more or less spindle-shaped or ovoid enlargement of the entire ankle occurs. In the very early stages the swelling is first noticeable upon the front of the ankle, on either side of the bundle of extensor tendons. Upon palpation the more or less characteristic doughy infiltration of the synovial membrane and surrounding structures is observed on palpation. Fluctuation can scarcely be detected in the joint. Indeed, a tuberculous hydrops of the ankle is a great rarity. Perforation of the joint capsule occurs most often upon the anterior or outer aspect of the ankle, and is followed by the production of characteristic tuberculous sinuses. Here, as in other joints, *atrophy of the muscles* of the calf is gradually developed, and such atrophy may from disuse involve also

the muscles of the thigh. As in other joints, *reflex spasm* causes marked limitation of motion in the ankle, and any attempt to move the foot produces a sudden contraction of the muscles, causing fixation of the joint. There is *pain*, usually of moderate severity, but rendered much worse by attempts to use the limb. *Tenderness* is usually present over the front of the ankle, and is most marked toward its outer aspect. The *position* assumed by the foot is one of *plantar flexion*, yet, in rare cases, moderate supination or pronation are added. The position of *pes calcaneus* is rarely observed. By means of the X-rays, owing to the superficial position of the bones; the situation and extent of the bony lesion, whether situated in the astragalus, os calcis, tibia, or cuboid, can usually be detected with considerable accuracy, as well as the extent of bony destruction.

FIG. 258.—TUBERCULOSIS OF THE SCAPHOID BONE OF THE FOOT. X-ray showing the bony destruction. Scaphoid removed by the author. Good functional result.

Fig. 258, in the text, is an X-ray picture of tuberculosis of the scaphoid bone, upon which I operated some months ago. The loss of bony structure is quite plainly shown. In this case, fortunately for the patient, the scaphoid was alone involved, and its removal, with careful dissection of the tuberculous synovial membrane, was followed by a cure and a good functional result. The diagnosis of tuberculosis of the ankle-joint is usually not difficult from the data already given.

In *children* the conservative treatment of tuberculosis of the ankle by fixation, or by fixation preceded by conservative operations, erasions, etc., is sometimes followed by favorable results. If the ankle-joint becomes ankylosed, the smaller bones of the tarsus acquire an unusual degree of mobility and the interference with the gait may be trifling. In *adults*, in my own experience,

the prognosis of tuberculosis of the ankle is quite unfavorable. Many of the cases have as an associated lesion, tuberculosis of the lungs. The results of treatment, either conservative or following resection of the ankle, have not in my own cases been particularly good. In a few a cure of the disease has followed removal of the astragalus or resection of the ankle-joint; in others the disease has recurred and has necessitated amputation.

In a few cases tuberculous foci either in the astragalus or in the os calcis are followed by invasion of the *calcaneo-astragaloid* joints. In these the swelling will be noted at a lower point than is observed in tuberculosis of the ankle-joint itself. The movements of the ankle-joint are less restricted than in those cases where this joint itself is involved. In many instances, however, the exact diagnosis of the seat of the process will only be made at the time of operation. The X-rays sometimes aid in differentiating the position of the joint affected.

Tuberculosis of the Os Calcis.—The os calcis is very frequently the site of a primary tuberculous focus. The disease often occurs in the depths of the body of the bone and may produce a considerable tuberculous sequestrum. The disease remains confined to the os calcis and perforates outwardly with the formation of a tuberculous abscess of the soft parts *without invading the ankle-joint in nearly half the cases.* In the cases in which the joints are secondarily involved, the ankle-joint or the joints between the os calcis and astragalus are those invaded. When the tuberculous focus perforates outwardly, an abscess, and later a sinus, will be formed upon the inner aspect of the same, or sinuses may be formed on either side of the tendo Achillis. Secondary involvement of the tendon sheaths, notably of the peronei, is quite common.

The signs and symptoms are, swelling of the posterior part of the foot with quite palpable thickening as the body of the os calcis is grasped between the fingers and thumb. There is pain on walking, and localized tenderness upon pressure over the affected bone.

The differential diagnosis between isolated tuberculosis of the os calcis and tuberculosis of the ankle-joint may usually be made from the fact that, in the former group of cases, the motions of the ankle-joint remain free, while in the latter they are restricted. Moreover, the swelling in tuberculosis of the os calcis does not involve the region in front of the malleoli. The various motions of the ankle and the lower tarsal joints, flexion and extension, pronation and supination, are not notably interfered with, whereas when the joints between the os calcis and astragalus are invaded, pronation and supination of the foot are restricted and painful. The location of the disease in the os calcis is, as a rule, readily demonstrable by means of the X-rays. The prognosis as to operative cure in tuberculosis confined to the os calcis is quite good. If, however, the disease is neglected, involvement of one or other of the neighboring joints is almost certain to follow.

Tuberculosis of the Smaller Bones of the Tarsus.—Tuberculosis of the smaller bones of the tarsus, the cuboid, the scaphoid, are attended by the signs of local-

ized pain, tenderness, and swelling over the affected bones. There is in these cases a strong tendency for the disease to advance and to involve numerous joints in the vicinity. The cuneiform bones and the joints between the cuneiforms and the metatarsals are often secondarily invaded. When seen at an early period it is often possible by physical examination and by means of the X-rays, to determine the origin and extent of the disease and the probable character of the operation necessary for its removal. After the tuberculous process has existed for some time, however, the extensive involvement of the soft parts and of other joints will render a diagnosis as to the actual limits of the lesion rather difficult without operative exposure. The movements of the ankle-joint itself are more or less completely preserved.

Tuberculosis of the Metatarsal Bones and Phalanges.—In the metatarsal bones and the phalanges of the toes, tuberculous inflammations resemble in their clinical characters those seen in the corresponding bones of the hand—namely, the production of a fusiform swelling of the bone, sometimes followed by abscess formation and sinuses. A typical *spina ventosa* is quite common. The spindle-shaped enlargements are more commonly observed *in children* than in adults. The *first* and *fifth* metatarsal bones are most commonly involved, and the joints at their bases frequently become the seat of tuberculous invasion. The diagnosis of these tuberculous lesions is usually not difficult, from the signs and symptoms characteristic of tuberculosis of bones and joints, as elsewhere described. The operative removal of all the diseased tissues gives these patients the best hope of cure.

TUMORS OF THE FOOT

Benign Tumors.—A great variety of tumors, both benign and malignant, occur in the foot. Among the benign forms may be mentioned the several forms of angioma, including nevus, together with cavernous angioma, and, as a great rarity, cirsoid aneurism. They possess the same characters here as elsewhere and need no special description.

Fibroma of the soft variety is occasionally observed in the sole of the foot. I removed some years ago a fibroma of this character from the sole of the foot of a man who had had the tumor as long as he could remember. It was a pedunculated mass about the size of a goose egg and grew from nearly the center of the sole. It had caused some inconvenience from its mechanical presence, but it occupied such a situation that the patient habitually kept it in the concavity of the sole, where it produced only trifling discomfort. Occasionally, as the result of prolonged walking and mechanical irritation, the skin over the tumor became slightly inflamed. I removed it by a simple operation.

Keloid may occur in the foot, notably among negroes, in the scars following burns, infected wounds, operation wounds, etc. They are easily recognized and require no separate description. Here, as elsewhere, however, they tend to recur after removal.

CHONDROMA.—Cartilaginous tumors occur in the foot, notably in connection with the metatarsal bones, less frequently with the bones of the tarsus and of these more commonly in the os calcis than in other situations. They are often multiple tumors, and although of slow growth may in time reach a considerable size and cause marked disability from interference with the functions of the foot. The diagnosis of these growths presents no difficulty. They are of stony hardness, firmly attached to the bone, of slow growth, and of a generally benign character, although here as elsewhere *malignant* forms of chondroma may occur which undergo myxomatous or even sarcomatous degeneration, or produce metastases, even without evidences of such degeneration. The purely cartilaginous tumors will cast but a faint shadow upon an X-ray plate. Combinations of chondroma with osteoma are occasionally observed. They are more often seen in the region of the heel than elsewhere. They may originate in the os calcis, are sometimes pedunculated, and the tumor may undergo fracture at the point of attachment to the os calcis, so that it may appear to have grown originally in the soft parts.

The OSTEOMATA are benign tumors and their diagnosis requires no special description. Their character and structure can be beautifully demonstrated in X-ray pictures. The commonest seat for the development of bony outgrowths is beneath or to one side of the great toe nail, the origin of the tumor being the terminal phalanx of the great toe. These little tumors have already been mentioned in the preceding chapter. As there stated, they are almost exclusively observed in young persons. They may have their origin from the periosteum or from the junction of the base of the phalanx with its articular cartilage. They may also arise, it is believed, from the connective tissue structures of the toe. In their early stages the chief symptom complained of is pain in the terminal phalanx of the toe beneath the nail, as the nail is slowly pushed from its bed by the growing tumor, and in this stage the diagnosis might be missed without a careful examination. Pressure over the toe nail causes notable pain, and the child usually limps while walking. While as a general rule no difficulty whatever exists in detecting the presence and nature of these little tumors, the X-ray might in exceptional instances be of use as showing a bony outgrowth from the dorsum of the terminal phalanx of the toe.

Among the benign epithelial tumors of the foot may be mentioned the hard, and more rarely soft papillomata, readily recognized on the foot as in other situations. If they are so placed as to be pressed upon by the shoe, they may become painful, irritated, and even ulcerated, and require removal. Among the benign epitheliomata occasionally observed upon the foot may be mentioned also epithelial implantation cysts, the result of trauma. They differ in no wise from such tumors when occurring in the hand and fingers.

The Malignant Tumors of the Foot.—EPITHELIAL CANCERS of the foot, usually of the squamous-celled type, nearly always originate in scars or in chronic ulcers resulting from burns, freezing of the feet, wounds with loss of substance,

syphilitic or tuberculous ulcerations, or other chronic sources of irritation. A peculiar case of rapidly progressive epithelioma of the foot involving the deeper structures and combined with pyogenic infection came under my care several years ago. The patient was a man aged thirty-five, who had suffered for a number of years from a bunion, which from time to time became the seat of pyogenic infection resulting in small abscesses. These were allowed to break or were incised, but no operative treatment calculated to effect a cure of the condition was used. When I first saw this patient he was admitted to my service in the New York Hospital with the history that some four months before, following an attack of inflammation of his bunion with abscess formation, the process did not proceed toward healing. The ulcer extended superficially and deeply, and the entire great toe and the ball of the foot became painful, swollen, tender, and reddened. From the surface of the ulcer a thin purulent discharge was given off, there were formed gradually, small, deep-seated pockets of suppuration which emptied themselves upon the ulcerated surface. As time went on the surface of the ulcer became covered with exuberant, hard, pale granulations. The raw surface took on a peculiar rough and granular character and the entire infiltrated portion of the foot became hard. When seen by me a correct diagnosis was not at first made. The condition seemed to be one of subacute and rather widespread and deep-seated pyogenic infection. Owing, however, to the peculiar hard quality of the tissues a small portion of the ulcerated area was excised, and under the microscope showed typical appearances of epithelioma, with pyogenic infection of the stroma of the tumor tissue. Amputation was done through the lower third of the leg. The wound healed per primam, and the patient passed out of observation. Upon section of the tumor tissue, it was found that the epithelioma involved the soft parts of the lower third of the foot, including the great toe and that the first metatarsal bone, together with the first phalanx of the toe, had also been invaded and were the seat of cancerous infiltration. (See Fig. 259 in the text.)

FIG. 259.—COMBINATION OF RAPIDLY INFILTRATING EPITHELIOMA OF THE FOOT, WITH ACUTE PYOGENIC INFECTION. Amputation of the leg. Operative cure. (Author's collection.)

When epitheliomatous degeneration occurs upon the sole of the foot at the site of callosities or of corns, the nature of the lesion may for a time remain unsuspected. The conditions may resemble those just described as occurring

in my own case, or during the early progress of the disease the ulcer ma resemble the slowly progressive forms of perforating ulcer of the foot, suc as occur in tabes. In cases of doubt, the removal of a section from the bas of the ulcer and its microscopic examination will establish the diagnosis.

Carcinomatous degeneration has also been observed to originate in con genital pigmented moles, and such congenital pigmented growths may also give rise to melanotic sarcoma. In either case the prognosis of these conditions is exceedingly bad.

Sarcoma of the Foot.—The sarcomata of the foot may arise from the skin, from the subcutaneous tissues and fascial layers, or from the bones. The sarcomata arising in the skin commonly develop, as already stated in a preceding paragraph, in moles and cutaneous angiomata. In some of the cases the moles are pigmented, in some they are not. In the former group a melanotic sarcoma will usually develop; in the latter one or other of the forms of sarcoma, or of endothelioma, or of perithelioma will be the result. The melanotic sarcomata, here as elsewhere, have the worst possible prognosis. I recall a case upon which I operated for a melanotic sarcoma of the sole of the foot. The growth had originated in a pigmented mole. The tumor had shown signs of active growth during a period of only three months, and yet within six months of the time the tumor was removed secondary pigmented nodules of sarcomatous tissue had occurred in the skin of various parts of the body, in the muscles, and in the liver.

The *peritheliomata* and *endotheliomata* of the foot and leg run a course which resembles that of the sarcomata. They show a tendency toward rapid infiltration of the surrounding tissues and to rather early ulceration with the formation of a mass of hemorrhagic soft tumor tissue which bleeds readily, one of the forms of the so-called "fungus hematodes." Occasionally sarcomata of one of several different types are observed in the great toe. Such may originate in the terminal phalanx of the toe, or in the soft parts at the border of the nail. Some of them are very malignant tumors. Some of them less so, according to the character of the cells composing them. During their early stages, if they cause swelling and ulceration at the border of the nail, they may be mistaken for ingrowing toe nail.

Sarcomata of the bones, originating in the foot occur with the greatest frequency in the metatarsal bones and in the phalanges of the toes, occasionally in the os calcis. They are here, as elsewhere, more or less rapidly growing tumors, and the periosteal forms are more rapid in their growth and more malignant than those occurring in the medulla and spongy tissues of the bone. The more rapidly growing forms may more readily be mistaken for tuberculosis, syphilis, or subacute osteomyelitis of the bone. The differential diagnosis may sometimes be made by the absence of the signs of acute inflammation and the presence of but little pain or tenderness, and yet mistakes are no infrequently made. If the disease has advanced far enough to cause bon destruction and absorption an X-ray picture may aid greatly in the diagnosis

The shadow of the bone will be notably less dense as compared with the sound side of the body and if the bone has undergone notable enlargement from irritation of the periosteum, the picture may be that of a *spina ventosa*. The rapidly growing sarcomata of the deeper soft parts of the foot have often been mistaken during their earlier stages for inflammatory processes, and such tumors have been incised by surgeons under the impression that they had to do with a deep-seated abscess. This will be a possible error in the cases of sarcoma which undergo cystic degeneration. Observation of such cases for a short time and incision will readily establish the diagnosis.

CHAPTER XXX

ACQUIRED AND CONGENITAL DEFORMITIES OF THE FOOT AND ANKLE, INCLUDING THE VARIOUS FORMS OF CLUB-FOOT

ACQUIRED DEFORMITIES

Hallux Valgus.—Hallux valgus is the name used to designate an outward displacement of the great toe. That is to say, the great toe is displaced toward the outer border of the foot. It is essentially a deformity of civilized life, caused by the pressure upon the great toe of improperly constructed or ill-fitting shoes and stockings. The normal position of the great toe is such that the central axis of the great toe being prolonged backward should pass through the center of the posterior border of the heel. This position of the great toe is, however, only seen in infants and among uncivilized races, who go barefoot. Among all adults who habitually wear shoes and stockings, some deviation of the great toe toward the outer side is commonly observed, but only when such deviation becomes excessive does it give rise to symptoms and become pathological. The deformity is frequently associated with flat-foot. The abduction of the great toe may amount to thirty, forty-five, or even in extreme cases to ninety degrees. Associated with the displacement of the toe there is formed over the metatarso-phalangeal joint upon its inner aspect a bursa, commonly known as a *bunion*, and this bursa frequently becomes the seat of a simple or infectious inflammation, and gives rise under such conditions to corresponding symptoms, pain, tenderness, swelling, sometimes to abscess formation. When such a bursa becomes infected with pyogenic germs it may perforate into the metatarso-phalangeal joint and cause its destruction.

FIG. 260.—EXTREME DEGREE OF HALLUX VALGUS. (Case of Dr. L. W. Hotchkiss, Bellevue Hospital.)

The other toes being crowded outward by the great toe, are pressed upon by the shoes and become the seat of callosities and of painful corns. The displacement outward of the proximal phalanx involves the metatarso-phalangeal joint in such a manner that a portion of the head of the metatarsal bone is uncovered and is subjected to undue mechanical irritation. Such exposure

frequently leads to absorption and destruction of a portion of the cartilage covering the head of the bone. The sesamoid bones are displaced outward, the internal lateral ligament of the joint is stretched and becomes thickened and the seat of chronic inflammatory infiltration. The repeated attacks of inflammation in the bursa overlying the joint and in the skin cause a chronic inflammatory thickening. In extreme cases the great toe rides upward and outward upon the dorsum of the second toe, less frequently beneath it. Occasionally a displacement of the second toe occurs dorsally with the production of hammer-toe, a condition to be described in the following section. From the above description the diagnosis of hallux valgus and of bunion is entirely simple. A variety of operations have been devised for the cure of bunion and hallux valgus. For their technic the reader is referred to works on operative surgery.

Hammer-toe.—A permanent hyperextension of the metatarso-phalangeal joint of a toe, with marked flexion of the first interphalangeal joint produces a deformity known as hammer-toe. The condition may in rare cases be congenital, but it is usually acquired and is due to the crowding together of the toes by improperly fitting and narrow shoes. The joint between the phalanges is very prominent dorsally, and over it, as the result of mechanical irritation and pressure, there forms a corn, and beneath that, a bursa. The second and third toes are most commonly affected. Upon the tip of the toe also, which is pressed downward against the sole of the shoe, there frequently forms a painful corn and sometimes also a bursa. The condition is an annoying and painful one. Its diagnosis is to be made upon inspection and requires no further description. In cases which are not highly developed, if the patients are young, improvement and even cure may sometimes be obtained by wearing proper shoes and by strapping the toe to a small plantar splint. In a few cases I have obtained good results by a tenotomy of the flexor tendon followed by strapping the toe to a suitable splint. In some of these it is also necessary to divide the extensor tendon of the toe. In more severe cases it is recommended to resect the first interphalangeal joint. In other cases I have found it necessary to amputate the toe, and in several of these, if the patient has been very careful to wear properly shaped shoes, no disagreeable after results and no tendency to the production of hallux valgus has followed.

In some cases a condition of marked flexion occurs in the four smaller toes. Such deformities may be the result of improper footwear, occasionally from paralysis of the extensors of the toes and the unopposed action of the flexors. It is also observed as a part of the lesion of pes cavus, and occasionally in pes equinus. The deformity is a painful one, since the prominent interphalangeal joints are constantly pressed upon by the shoes, the mechanical irritation resulting in painful corns. The treatment does not differ from that of hammer-toe.

The condition of *hallux varus* in which the great toe is abnormally adducted

is occasionally observed as a congenital deformity among infants, and may be a part of the lesion of talipes varus. The diagnosis is to be made upon inspection and requires no especial description.

Pes Planus (Flat-foot).—Flat-foot, *pes valgus*, a deformity in which the antero-posterior arches of the foot are weakened, so that the larger portion of the sole comes in contact with the ground when standing or walking, the deformity being usually associated with abduction of the foot, or pronation, is a very common condition. It may be congenital or acquired, the latter being far more common than the former. The *congenital form* of flat-foot is occasionally observed among infants, and in these the flattening of the arch may be associated with an imperfect development of some of the smaller bones of the tarsus, or with imperfect development of the bones of the leg, or, apparently, in other cases it may be merely the result of a weakness of the ligaments of the foot and of the ankle-joint. It is to be observed that all infants are born with flat-foot, or at least the appearance of flat-foot, since the normal, dense layers of fat which appear in later years are absent at birth. The appearance is a normal one and passes away with the growth of the child. Among the true cases of congenital flat-foot, not only does the sole of the foot appear to be flat, but there is also marked abduction (pronation) of the

FIG. 261.—DOUBLE FLAT-FOOT, PES VALGUS. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

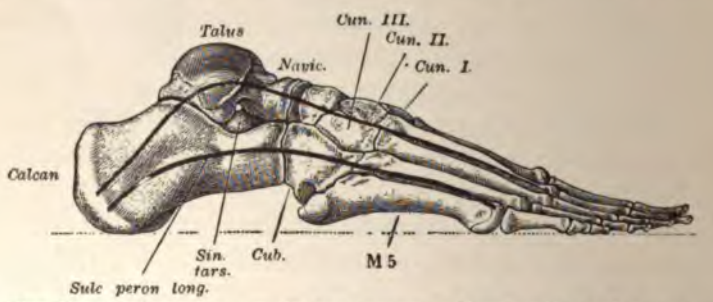

FIG. 262.—THE PROFILE VIEW OF THE SKELETON OF THE NORMAL FOOT, SHOWING THE ANTERO-POSTERIOR ARCHES OF THE FOOT. (After Merkel.)

entire foot. The inner malleolus appears unduly prominent, and the foot is notably displaced outward. *In the more severe cases it is not possible to bring the foot into normal relations with the leg.* The condition is readily enough recognized upon inspection and palpation of the child's foot. In these cases the

deformity may be corrected and the foot put up in plaster-of-Paris during the first year of life, and when the children begin to walk the sole may be supported by a suitable artificial arch in the form of a small light metal plate.

Acquired flat-foot may depend upon several causes. The underlying cause is, however, *a disproportion between the weight of the body and the power of the muscles and ligaments of the foot and ankle to sustain this weight.* In some cases the muscles and ligaments are weakened as the result of rachitis. In others the individual is possessed of abnormally weak and flabby tissues, either on account of mode of life, producing obesity, etc., from want of exercise, or from any depressing general cause, such as a prolonged illness.

FIG. 263.—IMPRINT OF A NORMAL FOOT, ADULT. (After Merkel.)

In another group of cases, as already mentioned in several sections of this book, the weakness depends upon a fracture of the leg or a rupture of the ligaments of the ankle-joint, such that not only are the ligaments weakened, but the proper line of support is lost. Normally, in the erect posture, the line of support of the leg should fall somewhere about the middle of the foot or opposite the line of the second toe. By far the most common cause of the breaking down of the arch of *a normal foot* is mode of life and occupation, such that the individual is obliged to stand upon hard floors for many hours, or is engaged in other laborious work which puts an undue strain upon the supporting structures of the foot. Thus, in a very large proportion of cases of flat-foot, we find that the patients are waiters, barkeepers, clerks who are obliged to stand for many hours behind a counter, or they are laboring men whose work is hard and keeps them standing on their feet for many hours a day. In another group of cases the patients are females who take but little exercise and who become obese. In this group the increased weight of the body results in abnormal strains upon the mus-

cles and ligaments of the foot and ankle. In other sections we have mentioned the deformities of the foot which may follow tuberculosis of the ankle, arthritis deformans, whether spontaneous or due to injury. Among the latter group imperfectly reduced Pott's fracture is one of the most frequent causes of flat-foot. In addition to these cases of acquired flat-foot, there may be mentioned paralysis of the muscles of the leg, whether due to cerebral apoplexy in the elderly, or to poliomyelitis in the young, or to nerve injuries. Flat-foot may develop in these cases when the muscles of the inner side of the leg are paralyzed.

Occurrence.—Flat-foot occurs with the greatest frequency during early adult life and is about as frequent in men as in women. The condition is more often bilateral than unilateral, although in a considerable proportion of cases one foot is affected first. The changes in the bones and soft structures as the result of flat-foot are that the entire foot is abducted while the normal antero-posterior arch of the foot is depressed or obliterated. The soft parts, ligaments and muscles upon the sole and inner border of the foot and upon the dorsum thereof, are lengthened and shortened, respectively. The changes in the bones are changes of position and relation rather than changes in the bones themselves. The position produced is an exaggeration of the normal yielding of the soft parts of the foot as the result of pressure. The entire lower extremity is slightly rotated inward. The front of the astragalus is adducted and also rotated inward. The second row of tarsal bones (scaphoid, cuneiform), together with the base of the first metatarsal, are depressed and displaced slightly toward the inner border of the foot. The displacement of the head of the astragalus and of the scaphoid bone varies in extent with the severity of the lesion. In very marked cases they lie almost in contact with the ground as the patient stands erect. The inner border of the foot becomes convex, while the outer border becomes concave.

The symptoms produced by flat feet vary in severity according to the extent of the deformity of the foot. In the mildest group of cases, where the condition may be more properly described as "weak foot," the patients complain of pain and tenderness, usually first referred to the sole of the foot beneath the instep. They have a sensation of fatigue, a feeling of weakness and of tension in the structures of the sole when they walk or stand erect, with more or less pain referred to the sole and to the heel. In more severe cases pain will also be complained of in the dorsum of the foot and behind the inner malleolus. In still more severe and neglected cases the patients, more especially if they are women, will complain of pain in the muscles of the calf and in the back. The pain is most marked after the foot has been used in walking or standing, and when, after having been in a sitting posture for some time, the patient is obliged to rise to his feet. The foot will then feel stiff, sore, and lame, so that the patient may walk irregularly and unevenly for some steps. Prolonged rest causes the pain to disappear. The gait in walking is stiff, awkward, and inelastic; the patients appear to be walking on their heels. In old and neglected

cases one often will observe a chronic congestion of the entire foot, the muscles of the leg may undergo a slight degree of atrophy. Other signs of a flabby habitus are often observed, such as varicose veins.

Diagnosis.—With a history of the above symptoms present to a more or less marked degree, the diagnosis of flat-foot is usually readily made upon inspection, notably in those cases where the deformity is well marked. In the slighter

Fig. 264.—Sole Prints of a Normal Foot; Boy, Aged Six. (After Taylor.)

cases, such as one observes in private practice, the diagnosis may be missed unless the surgeon takes pains to examine the foot somewhat critically. When patients come complaining of *rheumatism of the legs and feet,* it is unwise to make the diagnosis of myalgia, sciatica, or other indeterminate ailment without first causing the patient to take off his or her shoes and stockings, so that the foot may be critically examined for evidences of weakness of the arch. In the more marked cases the diagnosis can be made upon inspection. (See Fig. 261.) The abduction of the foot and the falling of the arch are evident at a glance. Two types of flat-foot are ordinarily described, in one of which the arch of the foot remains *flexible* and can be restored to a normal position upon manipulation and readily supported by suitable apparatus. In another group the deformity, after having existed for a certain time, is attended by

permanent shortening and lengthening in the ligaments and other soft parts, so that no ordinary manipulation is sufficient to bring the bones of the foot and ankle into their normal relations. Such deformities are also attended by muscular spasm, notably of the peronei muscles.

FIG. 265.—FLAT-FOOT OF MODERATE GRADE; IMPRINT OF THE SOLE. (Taylor, after Weigel.)

In addition to the deformity one will frequently notice callosities in unusual places where pressure has been brought to bear upon the sole, together with the formation of corns, the presence of hallux valgus, etc.

A determination of the area of the sole of the foot which comes into contact with the ground while the patient bears his weight upon the foot is an important aid in the diagnosis. It may be made in one of several ways. The sole of the patient's foot may be moistened in water and he may then be requested to stand upon a sheet of paper, or upon a thin sheet of shiny gutta-percha, or upon the polished japanned surface of a "squeegee" plate used in mounting photographic plates. Instead of water the sole of the patient's foot may be dusted with talcum powder. He is then requested to stand upon the smooth surface and to bear his weight upon the affected foot. If the arch of the foot be normal, a considerable concavity in the outline of the inner border of the foot will be observed. (See Fig. 263.) If the arch of the foot is weakened or lost, this concavity will be diminished or almost completely obliterated and the imprint of the sole will be much wider. (See Fig. 265.)

The following method of examination in the less severe cases of flat-foot is recommended by Lovett:[1]

A more reliable method is to have the patient stand on a glass table with a mirror placed underneath at an angle of 45 degrees, in which may be seen reflected the pressure areas in standing, which show as greenish-white areas. In the most normal foot, the outer border of the foot touches the glass, and in pronated feet, only two areas bear the weight, one under the inner side of the front of the foot and one under the inner part of the heel. The information thus obtained is of value only in connection with the clinical symptoms.

The changed relations of the bones in advanced cases of flat-foot are readily enough demonstrated by means of stereoscopic X-ray pictures. In examining

[1] R. W. Lovett, Keen's "Surgery," vol. ii, p. 556.

the flat feet of young persons, sometimes such stereoscopic pictures are valuable in that by this means it may be possible to show delayed ossification in some one of the tarsal bones—the cuboid or scaphoid, for example. In the less severe cases of flat-foot the diagnosis is partly to be made from the history of the development of characteristic symptoms, and by finding that when the

FIG. 266.—DELAYED OSSIFICATION (?) IN THE BONES OF THE TARSUS IN A CHILD SEVEN YEARS OLD. There was notable relaxation of the ligaments and marked flat-foot. (Author's collection.)

plantar fascia is put upon the stretch by the hand of the examiner marked tenderness is to be noticed beneath the instep. In these slighter cases the dropping of the arch may be but little marked, and in these the diagnosis is often best confirmed by finding the great degree of relief to the symptoms by the use of proper shoes with the instep suitably supported by a steel insole.

Pes Cavus (*Hollow Foot, Pes excavatus*).—A deformity of the foot the opposite of flat-foot, in which the arch of the foot is abnormally increased is known as pes cavus. The condition is quite frequently observed in combination with pes calcaneus and pes equinus. In a certain number of cases the condition is congenital, and in still others it is caused by wearing shoes which are too short for the feet. The deformity is produced artificially in China in the feet of girls of the upper classes, and the end result produces an extreme degree of pes cavus. In the milder cases, when the deformity exists alone, the foot is merely more highly arched than normal and the soft parts of the sole, notably the plantar fascia, are contracted. These patients suffer chiefly from pressure upon the dorsum of the foot by the shoe, and in walking the pressure is brought to bear chiefly upon the heel and the ball of the foot. Painful callosities and corns are thereby produced. There is often notable pain in the metatarsophalangeal articulations. The increased arch may be associated with abduction of the foot, pes valgus.

In addition to the congenital forms a hollow foot may be produced in a few cases by prolonged confinement to bed, although in these it is usually accompanied by more or less marked equinus. In a few cases it may follow slight degrees of paralysis of the anterior group of muscles of the leg due to poliomyelitis anterior, or to neuritis. In addition to the increased depth of the arch, the shortened plantar fascia renders the foot somewhat rigid.

The diagnosis is to be made by inspection and by palpation, the latter determining readily the presence of the contracted plantar fascia. If the tissues of the sole be put upon the stretch by dorsal flexion of the foot, the plantar fascia will stand out as a rigid band, tender upon pressure.

In slight cases these patients may be rendered comfortable by a somewhat highly arched shoe, arranged with a metal plate in the sole, such that the pressure is equalized. In severe cases forcible correction of the deformity under an anesthetic, with or without subcutaneous division of the plantar fascia, may be necessary to afford relief. If marked equinus is an associated lesion, division of the tendo Achillis may be necessary.

CONGENITAL DEFORMITIES

Congenital Defects of the Foot other than Club-foot.—Certain rare congenital deformities of the foot are occasionally observed, and while the diagnosis of the conditions can usually be made at sight, a few remarks in regard to some of the more common forms may not be out of place. An abnormal increase in size of one or both lower extremities is an occasional congenital deformity. If both lower extremities are of the same size the condition is of no surgical interest. If one extremity is notably larger than the other, deformities and disabilities may result, but, as a rule, orthopedic appliances will be sufficient to give the patient comfort in walking. These localized hypertrophies more often affect a part of a lower extremity than the whole, and in the majority of instances the increase in size is confined to the peripheral portion of the limb, the foot, or the toes, respectively. In a certain group of cases not the entire foot, but only the soft parts, notably the fat and subcutaneous tissues, may be increased beyond the normal size. In some of these cases the condition appears to be that of a diffuse congenital lipoma; in others of a diffuse fibro-lympholipoma, a congenital elephantiasis, in other words. In a moderate number of cases the blood-vessels of the part are locally or diffusely increased in size, and a diffuse hypertrophy of the skin and subcutaneous tissues may thus be associated with one or other of the forms of angioma. In some instances there may exist in combination with hypertrophy of the skin and subcutaneous tissues a diffuse fibroneuroma. In many of these there will be in addition abnormal pigmentation of the foot and associated angiomata, usually in the form of angioma simplex or nevus. The diffuse fibro-lipomata may be associated with hypertrophies of the skin and subcutaneous tissues, and then constitute one of the forms of congenital elephantiasis.

In a certain group of cases the congenital hypertrophy affects not the entire foot, but only one or more of the toes, such that the affected toe or toes may be several times the normal size. The causation of these various congenital deformities, though many theories have been advanced to account for their occurrence, still remains obscure.

As in the upper extremity, the peripheral portions of the foot may be increased or diminished in number. Children may be born with seven, nine, or even eleven toes on one foot, though more commonly there is but a single supernumerary toe. These supernumerary toes are observed more often associated with the first or the fifth toes than with the others. Sometimes the extra toe or toes possess the normal number of phalanges and have a corresponding metatarsal bone. In other cases one or other of the bones, usually the metatarsal, may be absent or incompletely developed. In a certain number, fusion between the metatarsals or phalanges of one or more toes is observed, and in this group of cases webbed toes (syndactylism) is common. In another group of cases the number of toes may be diminished and the congenital defect may involve one or several bones of the tarsus or metatarsus. The number of toes may be diminished to one or two, and these may be deformed in various ways. When there are but two toes, there is frequently a fissure throughout the center of the foot, so that the two toes come to resemble more or less a finger and thumb. The recognition of all these conditions is, of course, entirely simple upon inspection, and the deformities of the bones or their absence or arrest of development, respectively, can readily be demonstrated by means of X-ray pictures.

Talipes Equino Varus (Club-foot)

Club-foot is a congenital or acquired deformity characterized by marked supination of the foot, so that the sole looks not downward but inward, the outer border of the foot, or in extreme cases even the dorsum, rests upon the ground in walking; there is contraction of the soleus and tendo Achillis, so that the heel is elevated, and the front part of the foot is adducted as well as supinated. While the deformity of club-foot is recognizable at sight and cannot be mistaken for any other condition, a brief description of the lesions and varieties of these deformities of the feet is probably not out of place. As stated, club-foot may be congenital or acquired.

Congenital Club-foot.—The occurrence of congenital club-foot is fairly common. The deformity more often affects both feet than one, and is much more common in male than in female children. A certain small percentage, about ten per cent—namely, of congenital cases of club-foot—are associated with other malformations (spina bifida), other deformities of the spine and pelvis, meningocele, or hydrocephalus. In the remaining ninety per cent of the cases the deformities are confined to the foot. It is, I think, quite useless to discuss here the various theories which have been formulated to account for the deformity of club-foot. Suffice it to say that in the vast majority of instances

no cause can be assigned for this congenital defect any more than for other birth deformities. Among the congenital cases a small proportion only are associated with congenital deformity of the bones of the leg, notably of the tibia (see Congenital Defects of the Bones of the Leg), or with absence or arrest of development of one or more of the bones of the tarsus, the astragalus, the cuboid, the scaphoid. These cases constitute the exception. In the majority of instances no such defects are present.

The changes in the bones and soft parts in congenital club-foot may be briefly enumerated as follows: The foot is strongly supinated, the heel is elevated, the foot is in a position of plantar flexion and adduction. When the patient stands upright, the weight is borne in the mildest cases upon the outer border of the foot, and in more marked cases the supination is so extreme that

FIG. 267.—TALIPES EQUINO VARUS IN AN ADULT, CONGENITAL. The degree of deformity is less marked than in the other figures shown. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

FIG. 268.—CONGENITAL TALIPES EQUINO VARUS. The patient walked upon the outer border of his foot. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

the patient walks upon the dorsum. The degree of adduction also varies, and in extreme cases is so great that the foot points not forward but directly inward. Accompanying these changes of position, the shape and relations of the bones of the foot are altered from the normal. The astragalus is rotated forward upon a transverse horizontal axis; its neck is elongated. The posterior portion of the articular surface of the astragalus is in contact with the tibia and fibula. The head of the astragalus points downward and inward. The neck of the bone is longer than normal and is also twisted in a downward and in-

ward direction. The articular surface for the scaphoid therefore points not forward but downward and inward. Owing to this change in the position and shape of the astragalus, the bones of the forefoot are also changed in position and direction, and the scaphoid rests upon the inner part merely of the articular surface of the astragalus. In extreme cases the scaphoid may be turned so far inward that it rests upon the inner malleolus.

Changes in the position and shape of the os calcis are also observed. The bone is smaller than normal, its posterior portion, or the heel, is but poorly developed and short. The anterior part of the bone is, like the astragalus, bent and twisted downward and inward. Owing to these changes of shape the cuboid and the fourth and fifth metatarsals are displaced in a similar way to those whose articulations are connected with the astragalo-scaphoid joint. All the soft structures upon the sole and inner border of the foot are shortened. The skin, the subcutaneous tissues, the plantar fascia, the tendons, and the ligaments are all alike affected. The tendons passing across the sole of the foot are all more or less displaced toward the inner side. For the several degrees of club-foot the reader is referred to the illustrations in the text.

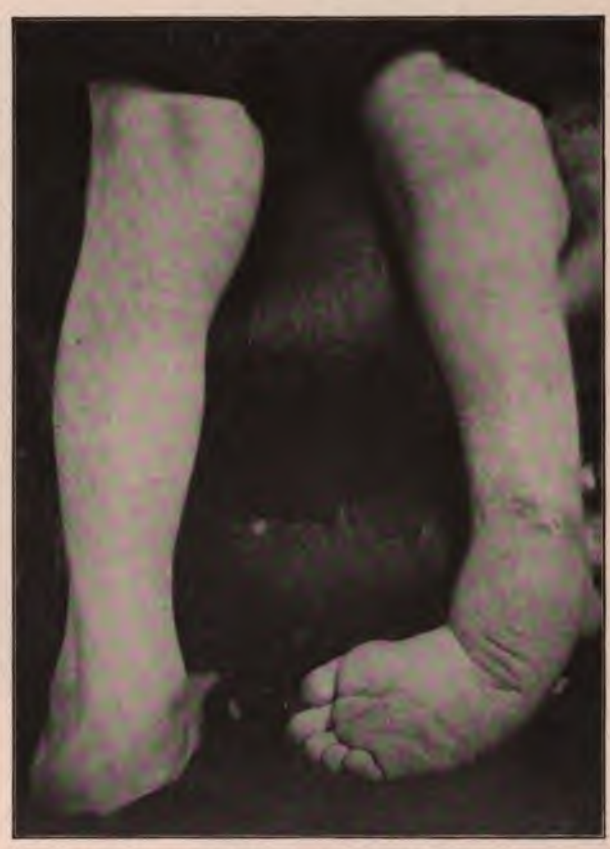

FIG. 269.—CONGENITAL CLUB-FOOT SIMILAR TO THAT SHOWN IN FIG. 268. The patient being a child had not developed so extreme a degree of deformity as the adult shown in Figs. 270 and 271. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

In addition, it may be said that if these patients continue to walk upon the foot, callosities are formed at the points of pressure, and frequently a considerable bursa, either on the outer border of the foot or upon the dorsum, according to the part pressed upon. Since the muscles of the calf are but little used in locomotion, they undergo a partial atrophy and the spindleshank appearance of these cases is very marked indeed.

The *symptoms of club-foot* are, that, in the double cases the inward projec-

tion of the foot and toes causes interference in walking, so that these patients must walk straddling slightly, and the gait has a peculiar stiff, ungainly, and clumsy quality. The longer the condition remains untreated, and the more the patient uses the foot, the more extreme does the deformity become, the greater the changes in the bones and in the soft parts and in the relations of the bones entering into the articulations.

In the mildest cases, when examined soon after birth, it is possible by gentle manipulation to more or less completely correct the deformity, and if

FIG. 270.—CONGENITAL TALIPES EQUINO VARUS, VIEWED FROM IN FRONT. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

FIG. 271.— CONGENITAL CLUBFOOT SHOWN IN FIG. 270, VIEWED FROM BEHIND.

such manipulations are carried out several times a day gently, short of giving the patient pain, the deformity may be nearly or quite overcome in the course of a year or two. In the more severe cases operative treatment of one sort or another is indicated. The author would express his preference in these cases for cutting operations with suitable wedge-shaped osteotomies and divisions of tendons and other soft structures with the knife, rather than for the method of forcible reduction by blunt violence. The former method of treatment gives good results, whereas the latter is sometimes followed by sloughing, ulceration, laceration of blood-vessels, gangrene, and even by death.

Acquired Club-foot.—A variety of causes may produce acquired talipes-equino-varus. Among these may be mentioned diseases of the joints—tuber-

culosis and arthritis deformans, for example, although such joint lesions never produce the degree of deformity noted in the congenital variety. Extensive fractures, notably with loss of substance, of the lower portion of the leg and of the bones of the tarsus, extensive injuries of the soft parts, with loss of substance, whether due to sudden mechanical violence or to the destruction of tissue produced by scalds, burns, electrical burns, may give rise, partly by cicatricial contraction and partly by loss of substance in the bones to a deformity of the foot which more or less closely resembles congenital talipes-equinovarus. The most frequent causes of acquired club-foot are, however, diseases of the nervous system, or injuries of the nerves resulting in paralysis of the muscles of the leg. The most frequent disease of all is *anterior poliomyelitis*. Other injuries and diseases of the spinal cord may cause some of the varieties of club-foot. Among them may be mentioned cerebral palsies, Friedrich's ataxia, and spastic paralyses. Progressive muscular atrophy may also be mentioned as an occasional cause, notably when the peronei are chiefly affected. In the acquired cases of club-foot about eighty per cent are due to anterior poliomyelitis, about ten per cent to cerebral lesions, and the remaining ten per cent are distributed among cases of neuritis, nerve injury, either of the peripheral nerves or of the cord, and to trauma of the foot itself—i. e., the contraction of scars and fractures. As might be gathered from its causation, acquired club-foot is commonly unilateral. The deformity is rarely so complete and typical as in the congenital forms. In the cases due to anterior poliomyelitis, the original paralysis improves, up to a certain point, and after a time becomes stationary or nearly so.

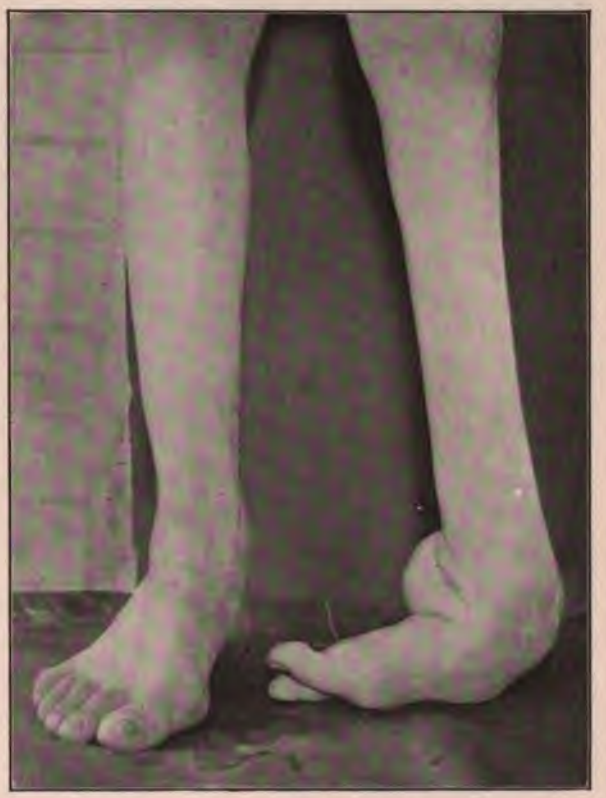

FIG. 272.—EXTREME DEGREE OF EQUINO VARUS, CONGENITAL. The patient bore his weight upon the dorsum of his foot. (Case of Dr. C. L. Gibson.)

The method whereby the paralysis of groups of muscles of the leg causes club-foot deformity is partly due to the unopposed contraction of nonparalyzed mus-

cles, tending to pull the foot constantly into some exaggerated position, partly through the force of gravity, which tends continually to produce plantar flexion, and when the patient comes to walk upon the partly paralyzed member the deformity tends thereby to be increased. The most frequent group of muscles to be paralyzed in this disease is the anterior tibial, and this accounts for the position of plantar flexion produced by the unopposed action of the muscles upon the back of the leg. The position of equinus is thereby produced, and after a time the contracted muscles become permanently shortened, so that, unrelieved by operation, the deformity is permanent. If both anterior and posterior groups of muscles are paralyzed, the deformity of the foot will not become marked until the patient begins to use the limb, when it will be created by bearing weight upon the paralyzed part. If these cases are neglected and the patient continues to walk upon the limb, similar changes in the bones and soft parts occur to those observed in congenital cases of club-foot.

FIG. 273.—PES VARUS THE RESULT OF POLIOMYELITIS ANTERIOR. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

The character of the deformity depends, of course, to some extent upon the distribution of the paralysis. If all the anterior group of muscles are paralyzed, the most marked deformity will be that of *equinus*. If, on the other hand, the tibialis anticus alone is paralyzed, the tendency will be toward the production of *equinus* combined with *valgus*. If the posterior group of muscles, the muscles of the calf, are paralyzed, the resulting paralysis tends toward the production of *pes calcaneus*, the foot being drawn into the position of dorsal flexion by the muscles of the front of the leg, so that the patient walks upon the heel. If the peronei are paralyzed the deformity produced tends to be supination of the foot or *varus*. It is to be borne in mind in the care of children suffering from anterior poliomyelitis that acquired club-foot can be avoided in nearly all cases by proper care during the illness. The weight of the bedclothes should be kept from pressing the feet down in plantar flexion;

the bedclothes should be supported by a suitable cage, or the like. Daily passive motion of the ankle-joints and of the joints of the tarsus should be practiced in order to preserve the motions of the joints and to prevent fixation in an abnormal position. While the patient is resting quietly in bed, the soles of the feet should be suitably supported. After the patient is able to get about, the feet should be kept in a normal position by means of some supporting apparatus.

FIG. 274.—PARALYTIC DROP-FEET, DUE TO POLIOMYELITIS ANTERIOR. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

Talipes Equinus.—Talipes equinus is the condition in which the foot is in a position of permanent plantar flexion. The deformity may be congenital or acquired, the latter group being much more frequent. As a congenital condition, talipes equinus is rare, and usually the deformity can be overcome by simpler measures than are necessary when marked varus coexists. It is sometimes necessary to divide the tendo Achillis. The acquired forms of talipes equinus are due to the same causes which produce acquired talipes equino varus, that is to say, anterior poliomyelitis; cerebral palsies; local affections of the nerve-trunks, whether due to injury or disease; traumatisms, whether of the bones or soft parts; diseases of the joints; and prolonged confinement to bed, when due attention is not paid to the position of the feet. In addition, talipes equinus may develop as a compensatory condition, when, following fractures or diseases of the bones of the leg, the extremity is permanently shortened, so that the foot must be placed in plantar flexion before the toes can be brought in contact with the ground. Whereas, loss of substance due to traumatism upon the inner border and sole of the foot produces talipes equino varus, similar lesions upon the posterior aspect of the ankle and leg produce the equinus position. The most frequent causes are poliomyelitis and neglect to keep the patient's feet dorsally flexed and mobile during prolonged confinement to bed, such as follows fractures or other grave injuries, typhoid fever, etc. The deformity may exist in several grades. In the slightest form the patient walks upon his toes and the front part of the foot, but is not quite able to bring the heel down to the ground. There is thereby produced a moderate limp. In the more severe grades the arch of the foot is notably increased, the patient walks

upon the dorsal surfaces of his toes. The condition entails a good deal of pain and disability. In still more marked types the toes are bent so far beneath the foot that the patient walks upon the dorsum of the foot itself. The condition entails grave disability.

Talipes Calcaneus.—In this condition the deformity is one in which the foot is permanently held in a position of dorsal flexion, so that the front part of the foot is raised from the ground in walking and the patient walks upon his heel. As a congenital condition, calcaneous is rare, and is never of such serious significance as in typical cases of club-foot. In the acquired forms the deformity is due more often to anterior poliomyelitis with paralysis of the muscles of the calf than to any other cause. In some of the cases a more or less marked valgus is an associated deformity and the arch of the foot is frequently exaggerated. As in the other forms, pes calcaneus may be the result of joint diseases, of injuries to the bones, or to the soft parts. The prognosis of the condition depends largely upon early and intelligent therapeutic measures. If the deformity is neglected, permanent changes occur in the bones, joints, and soft parts, such that correction of the deformity may be difficult or impossible. The gait is a stiff and nonelastic one, although the degree of disability and suffering entailed is not as great as in talipes equina varus.

It is to be borne in mind that all the forms of club-foot may be more or less closely simulated in HYSTERIA, but more especially pes calcaneus and pes equinus. As was stated when speaking of traumatic hysteria, the differential diagnosis must be made by search for hysterical stigmata—i. e., limitation of the visual fields, anesthesia, etc., and the fact that under general anesthesia the muscles relax and the deformity can be more or less completely overcome.

APPENDIX

NOTES ON A CASE OF RUPTURE OF A POLYCYSTIC KIDNEY

Polycystic kidney, as related in the section in Vol. II devoted to that topic, is a very rare disease. A few additional data in regard to it are here given.

Preitz, quoted by Watson, found in the records of the pathological institute of Kiel 16 cases of polycystic kidney among 10,000 autopsies. Watson says that in the record of 2,429 autopsies occurring during the last ten years at the Boston City Hospital, there were 10 cases. The pathology of the condition is sufficiently described in Vol. II, and, as there stated, the occurrence unilateral polycystic kidney in the adult is rare. Thus, Lejars (*Thèse de Paris*, 1888, p. 12), also quoted by Watson,[1] found only 2 cases among 63 adults in which the disease was unilateral, and Seiber in an analysis of 149 cases found only 9 in which but one kidney was affected. Cystic formations are not infrequently associated in other organs, notably the liver. The disease in adults is rare before the twentieth year of life, and is most common between the twentieth and fiftieth years. Thus the cases are divisible into two groups, those which are congenital, or are observed in early infancy, and those which do not appear until adult life. The pathology of polycystic kidney still remains obscure. By many it is believed that whether observed in infants or adults, the cystic changes depend upon some early disturbance in the development of the organ. The cases as they occur in adults run a course of somewhat variable length, usually extending over a period of years (see also Vol. II) and ending in death. In many instances the onset of the disease is insidious, and no symptoms at all may occur in bilateral cases until the patients either suddenly develop uremia or suffer from a cerebral apoplexy, since arteriosclerosis is a concomitant of polycystic kidney in fully twenty-five per cent of the cases. (Albarran and Imbert.)[2] The disease has been divided into three stages by Milward. During the first stage, which may last for months, or years, during which there may be no subjective symptoms, there is a slightly progressive enlargement of the kidney. In the second stage, tumor formation becomes appreciable, and this stage may last for an indefinite time. In the third stage in the bilateral cases, the symptoms are those chiefly of acute or chronic uremic poisoning ending in death. During the second stage, in addition to the pres-

[1] Watson and Cunningham, "Genito-urinary Diseases," vol. ii, p. 270.
[2] Albarran and Imbert, "Les Tumeurs du Rein," Paris, 1903, p. 570.

ence of a tumor, pain of a dull aching character referred to the site of the kidney, or, in the case which I am about to describe, to the epigastrium, and believed to be due to gastric dyspepsia is a fairly common symptom. The other symptoms observed are those of advancing interstitial nephritis. In regard to the pain in the course of the disease, it may be said that in some cases it resembles renal colic. In a personal communication Dr. Frank Hartley informs me that he had under observation several years ago a gentleman who suffered from bilateral polycystic kidney. He came to the hospital suffering with severe pain, resembling renal colic. The large tumors were readily palpable on either side of the abdomen. One of them was exposed through an incision and the diagnosis thus confirmed of polycystic kidney. Several of the cysts were punctured and the wound was closed. The patient did well, but suffered during his stay in the hospital from a sudden attack of intense pain in both loins and an increase in the size of the tumors. Suddenly, without special cause, the patient ceased to have pain, had an enormous polyuria which lasted for a day or more, and upon physical examination the tumors were found to have greatly diminished in size. Dr. Hartley informs me that one or more such attacks have occurred since, and that for a considerable period after one of these attacks the kidneys remained comparatively small for a number of months. They were still palpable, but had greatly diminished in size.

In the case, colored photographs of whose kidney are shown in the plates, the patient was a man, aged thirty-four years, who entered my service in the New York Hospital on Sunday, May 23, 1909, with the following history:

He had enjoyed throughout his life reasonably good health and had never suffered from any symptoms referable to his genito-urinary tract. He was said to have had an attack of malarial fever, acquired during a visit to Cuba. During the past few years he has had from time to time attacks of pain referred to his epigastrium, for which he had consulted several physicians, who had made a diagnosis of gastric dyspepsia of indeterminate causation. The attacks were not very severe and were never referred to the region of the kidney.

On Saturday evening, the day before admission to the hospital, while about to descend the stairs of an elevated railway station in Brooklyn, he caught his heel in the rubber matting and pitched headlong down a flight of steps. He was rendered unconscious by the fall, was picked up by a patrol wagon, and taken to the police station. He regained consciousness a few moments after he was hurt, and felt well enough in a short time to proceed to his home in the City of New York. He received several contusions of the face and scalp, but no other injuries of which he was conscious except that he suffered a moderate amount of pain in the left loin. He went to bed and slept fairly well. The next morning he observed that his urine was bloody, and at about the hour of three in the afternoon he came to the hospital in a cab. I saw him about an hour later.

He was a fairly well-nourished individual, rather slender than stout. He said that for some time he had had a chronic cough. There were no external

RUPTURE OF A POLYCYSTIC KIDNEY. (Author's case.)

evidences of injury except the contusions of the face and scalp and a small abrasion in the mid-axillary line opposite to the seventh rib upon the left side. Urine passed after he entered the hospital was of a deep port-wine color. The heart and lungs appeared to be normal. His temperature was not elevated, his pulse was 90. He complained of a sense of distention and soreness in the left side of the abdomen and loin, just below the ribs.

Physical examination showed that the left loin was occupied by a considerable tumor mass extending downward to the level of the umbilicus and within two inches of the median line in front. The mass extended upward beneath the ribs. It was flat on percussion, and the colon, displaced somewhat toward the inner side, lay in front of it and produced an area of tympanitic resonance. The left side of the abdomen over the tumor was markedly rigid and quite tender. The patient looked rather pale and anemic, and a diagnosis was made of a rupture of the left kidney with a large perirenal retroperitoneal hematoma.

The patient's condition being good, I did not operate upon him until the following morning. Under gas and ether an incision was made parallel to the ribs upon the left side, beginning at the outer border of the rectus in front, two inches below the costal margin and extending backward and outward slightly convex downward to the outer border of the erector spinæ muscle. Upon opening the loose perirenal fat, a hematoma of moderate size was entered; but further explorations showed the presence of a large polycystic kidney, which was ruptured horizontally at the junction of the upper with the middle thirds of the tumor. The illustrations are about one third the size of the organ. The rupture was on the anterior aspect of the growth and almost completely separated it into two parts.

Upon palpation of the opposite kidney through the wound, it appeared to be of normal size and consistence. The kidney upon the left side was removed without difficulty and with trifling hemorrhage. The ureter appeared normal and the renal artery and vein were of about normal size. The wound was sutured, with a suitable gauze drain left at its posterior angle. The patient did not suffer from shock and continued to pass abundant urine. The wound healed *per primam*, except for the drainage opening.

Upon the third day after the operation the patient passed seventy-two ounces of urine, and at present, three weeks after the operation, is passing from forty to fifty ounces a day. The urine, however, shows evidences of a moderate nephritis. It is of a specific gravity of 1.012, contains a perceptible trace of albumin, together with granular and hyaline casts. The patient has a moderate cough, with very little expectoration, in which no tubercle bacilli have been found. The probabilities seem to be that he will survive, but whether or not his remaining kidney will continue to functionate, whether he will die eventually of nephritis, or, on the other hand, whether the organ will undergo a similar cystic change, it is at present impossible to say. The interesting features of the case are that the tumor had never produced any definite symp-

toms, and that it should only have been discovered after its accidental rupture, the latter accident being, so far as I am aware, unique:

NOTE.—Since the above was written, three months ago, the patient has apparently made a complete recovery.

NOTES ON THE DETECTION OF THE NEGRI BODIES IN RABIES

Since the article in Vol. I on Rabies was written, a new method of staining has been devised which is rapid and is believed to give more certain and satisfactory results. The method was devised by Dr. Harris, of the Health Department of St. Louis. My attention was recently called to it through the kindness of Prof. Mazyck P. Ravenel. The method is as follows: Fix in methyl alcohol one minute; wash in order to remove alcohol; immerse in *old* saturated solution of alcohol soluble eosin one to three minutes (ninety-five per cent alcohol); wash two or three seconds in order to remove excess of eosin; immerse in free solution of Unna's alkaline-methylene blue five to fifteen seconds; wash in water; decolorize in ninety-five per cent alcohol, and follow with absolute alcohol, xylol, and balsam, or blot and dry in the air. The entire process requires less than five minutes.

The essential part of the method is that the alcoholic solution of eosin must be *old.*

THE PARATHYROID GLANDS

Although the presence of the parathyroid glands was known to pathologists (Virchow in 1863 and Remak in 1855) they were first described accurately by Sandström in 1880. They were regarded by him as portions of embryonic thyroid tissue. They were rediscovered by Gley in 1891. He, like Sandström, discovered but two of these bodies—namely, the lower ones. Gley discovered in part the importance of the parathyroids for the organism, and by experimentation showed that in animals, if he removed the external parathyroids, together with the thyroid, the animals suffered from *tetany.* If, on the other hand, the parathyroids were permitted to remain tetany did not follow. Since that time a large number of investigators have busied themselves with the physiological functions and pathology of the parathyroids. In America a large amount of this work has been done by W. G. MacCallum in Baltimore, at present at the head of the Pathological Department in the College of Physicians and Surgeons of the Columbia University. Much work and a number of interesting observations have also been made on the parathyroids by W. S. Halsted, of Baltimore. The results of their investigations together with references to the literature of the subject may be found in Johns Hopkins Hospital *Bulletin* (1905, xvi, 87), also Johns Hopkins Hospital *Bulletin* (1908) and *British Medical Journal* (1906, ii, page 1282). For the report of a case and a bibliography, see "Tetany Parathyreopriva," by Eugene H. Pool (*Annals of Surgery,* October, 1907, page 507). For the description of a case in the human

being of the symptoms of incomplete extirpation or of temporary interference with function of the parathyroids, see Halsted (*American Journal of the Medical Sciences*, July, 1907). The following data in regard to the anatomy of the parathyroids is quoted from W. G. MacCallum (*British Medical Journal*, 1906, ii, 1282).

There are usually four parathyroid bodies in man as well as in the lower animals. MacCallum states that in obese persons, or in those who have suffered from wasting diseases, the parathyroids may be hard to find, but when once found they are easily recognized, and that they may be distinguished from accessory thyroids, lymph nodes, and other structures. The average size of the parathyroids is from 6 to 8 by 3 by 1 to 2 mm. In some cases the bodies are as large as 1 cm. by 4 to 5 mm., in other cases they are much smaller. In shape they are flattened, usually elliptical or tongue-shaped, and quite soft. Their soft, flabby consistence aids in distinguishing them from bits of thyroid tissue, which are notably more firm and elastic, or from lymph nodes, also more firm.

Their surface is smooth and glistening and except for the red lines of minute vessels it is homogeneous in appearance, differing in that respect from the grayish pink or red lymph nodes, in the surface of which the gray lymph cords can generally be made out. They are of a clear light-brown color, though they may be pale in anemic subjects and in obesity. When congested they appear brownish-red.

Their bright-brown color, together with their softness, are the characters which render them easily recognizable.

Situation.—The parathyroids lie along the posterior inner edges of the lateral lobes of the thyroid, as a rule, though variations are numerous. MacCallum says:

It is often quite difficult or impossible to find both of them on each side; one or more may lie on the lateral aspect of the thyroid or even on the part of the trachea below the thyroid as far as the bifurcation.

The glands bear no definite anatomical relation to the recurrent laryngeal nerves. MacCallum describes the parathyroids in man as occurring in two pairs, as a rule, an upper and lower. He says:

In most instances the lower and larger glands lie near the posterior edges of the thyroid lobes in the loose tissue which fills the notches just above the rounded lower lobules, and on the branches of the inferior thyroid arteries which enter the thyroid at those points. In most cases the upper glands lie against the esophagus, at the points where the superior thyroid arteries fade away along the posterior edges of the thyroid lobes.

In dogs the glands may be embedded in the thyroid itself. MacCallum did not find that such was the case in human beings. Accessory thyroid glands are frequent in animals. They may also occur in man.

The parathyroids are believed to be derived from the epithelium lining the third and fourth branchial clefts. In structure the parathyroids belong to the group of ductless glands. They are surrounded by a thin fibrous capsule which sends delicate septa into the interior. The glandular substance is made up of epithelial cells containing large nuclei embedded in a rich capillary network. Minute cystlike cavities have been observed in the glands, containing a form of colloid material. Chemically, the blands are found to contain glycogen. The most important surgical interest attaching to the parathyroid bodies is that *their operative removal during thyroidectomy is followed by tetany.*

Removal.—It has long been known that in man and the lower animals the complete removal of the thyroid gland was followed in certain cases by convulsive seizures, characterized by generalized convulsions, together with spasmodic contractions of groups of muscles, notably in the upper extremity, the contraction of the muscles of the hand and forearm, producing the position known as "accoucheur's hand," a rapid and labored respiration, salivation, and death, sometimes in a few hours, sometimes after a period of several days, preceded by stupor and coma. There is not, as a rule, a marked elevation of temperature, nor is the pulse-rate notably accelerated. The symptoms may follow in from two to five days after the operation. In other cases, for reasons not entirely clear, such symptoms may be postponed for several months. At the present time it is certain that this peculiar train of symptoms depends not upon the total removal of the thyroid, but upon the fact that the parathyroids are removed or seriously injured at the same time. For this reason, at present, when a large part of the thyroid is to be removed, preservation of the posterior part of the capsule is carefully practiced, so that the parathyroids may be avoided. In certain cases incomplete extirpation of the parathyroids, or temporary interference with their function as the result of impairment of circulation or mechanical injury during operation, may be followed by a milder form of tetany, which has been designated by Halsted "subtetanic hypoparathyreosis." A case of this kind is described by Halsted in the *American Journal of the Medical Sciences,* July, 1907.

It is somewhat difficult to account for those forms of tetany which occur in gastric dilatation, etc., as described in Vol. II, on the supposition that this form of the disease is also due to disturbances of the parathyroid glands. MacCallum, from his experiments upon animals, concludes that in animals deprived of their parathyroids a poison exists in the blood which combines with certain cells in the central nervous system, and that it is one of the functions of the parathyroid glands to destroy or render innocuous this poison. This conclusion might explain the occurrence of certain cases of gastric tetany if we conclude that in these the parathyroids were inactive or unequal to their task. Indeed, certain facts would seem to indicate that this is the true explanation. Thus, MacCallum found at autopsy in a case of gastric tetany an increased number of eosinophile cells and evidences of beginning proliferation in the principal

cells of the parathyroids, and he regarded these changes as evidences of hyperplasia following functional insufficiency of the parathyroids.

Other observers, however, have found the parathyroids unchanged in cases of gastric tetany. Pregnancy and menstruation appear to predispose to tetany in women. Hemorrhages into the parathyroids have been observed in certain cases of infantile tetany.

Effect on the Calcium Metabolism.—The observations of MacCallum and Voegtlin seem to show that the parathyroids exercise some sort of control over the calcium metabolism. It has been noted that animals fed on milk containing a large amount of calcium do not develop tetany so readily as others, and that the symptoms of tetany in dogs can be caused to disappear at once by the injection of a solution of a calcium salt into the jugular vein. The effects of the injection last for a day or more, when the symptoms return, but can again be caused to disappear by another injection. It has also been observed that in cases of tetany there is an increased amount of calcium in the urine, whereas the amount of calcium in the blood is diminished. In regard to the treatment of postoperative tetany due to removal or destruction of the parathyroids, it is to be observed that as yet no satisfactory treatment has been devised. The symptoms may be ameliorated by feeding the animal, or the individual, upon beef parathyroids, as demonstrated by Halsted, and, as stated, by injection into the venous circulation of calcium salts, but these measures are only temporary and in bad cases do not save life. Avoidance, therefore, of injuring the parathyroids when operating upon the thyroid gland is very important. Halsted has shown that the parathyroids may be transplanted successfully, and, if during an operation it is discovered that one of the parathyroids has been removed, it should be transplanted at once either into the thyroid or into the subperitoneal tissue of the anterior abdominal wall, or into the spleen. (See W. S. Halsted, *American Journal of Medical Sciences*, vol. cxxxiv, No. 1, July, 1907.) Von Eiselsberg grafted the parathyroid into the rectus muscle in a postoperative case of tetany with success. Injections of parathyroid emulsion were made by Branham in a case of accidental removal of one or more of the parathyroids. In this case, however, some of the parathyroid tissue remained and resumed its function.

Relation to Convulsive Conditions.—A number of other convulsive conditions have been thought to bear some relation to the parathyroids. Among them may be mentioned epilepsy and paralysis agitans, eclampsia and myoclonus, and it has been supposed that parathyroid disease might bear a causative relation to osteomalacia and rachitis. The function of the kidneys also has been thought to bear some relation to the parathyroids.

Tumors of the parathyroids have been observed in a number of cases, the tumor being in the nature of adenoma, sometimes of considerable size. Tuberculosis of the parathyroids, cystic and fatty degeneration, and colloid degeneration have also been described.

RECENT IMPROVEMENTS IN X-RAY APPARATUS AND X-RAY TECHNIC

The improvements in X-ray apparatus and X-ray technic during recent years have been in the direction of the production of coils, and static machines capable of delivering a larger amount of electrical energy through the tube in a given time; of tubes of larger size permitting the continuous use of a large amount of energy for a longer period; of devices for the protection of X-ray patients and operators against burns; and of mechanical devices, some of them automatic, whereby the amount of electrical energy both in the primary and secondary circuits can be accurately controlled and measured; of mechanical devices for the more perfect production of stereoscopic pictures, and of apparatus for the viewing of stereoscopic pictures; and, lastly, of transformers constructed in such a manner that either the direct or the alternating current may be used as a primary source of energy, and that in either case the impulses pass in but one direction, and that, further, the current is rhythmically and rapidly interrupted, *so that no other interrupter is required.*

In regard to X-ray coils, it may be said that the improvements consist in changes in the winding of the primary coil and in the manufacture of the core, such that a secondary discharge of increased ampèrage is delivered by the secondary. This increase in the quantity of the secondary discharge excites the X-ray tube to give off a larger quantity of rays in a given time and permits the times of exposure to be greatly diminished in length. Thus, at present, X-ray pictures of the head may be taken in from ten to fifteen seconds, pictures of the kidney region in five seconds, pictures of the thorax may be taken, such that the heart and the diaphragm give a fairly sharp outline upon the photographic plate, and pictures of the thinner parts of the body require a second or a fraction thereof. These very short exposures produce X-ray negatives of great sharpness and wealth of detail. Not only the bones, but also in many instances the thicker soft parts can be more or less clearly portrayed, especially if stereoscopic pictures are made. The most modern static machines are made with very numerous plates of large size, and these machines deliver a quantity of energy which compares very favorably with the best coils.

In regard to tubes, the tubes are made much larger than formerly, and the increase in size permits the discharge of a large amount of current for a considerable number of seconds without undue heating effect. The most practical and efficient cooling device appears to be the use of a metal backing attached to the anticathode, the device, namely, used in the Gundelach tube. Copper appears to be an efficient metal for this apparatus, since it is an excellent conductor of heat. For the purpose of regulating the vacuum in the tube, the method of reduction used in the Gundelach tube, as described in Vol. I, is as efficient as any. The device formerly used in the queen tube, also described in Vol. I, or some modification thereof, is also used in certain

tubes. The best tubes made in America to-day appear to be those in which these two devices of air cooling through a large surface of metal and of the regulation of the vacuum by secondary adjustable spark-gap is used. The device used to prevent the occurrence of the secondary discharge in the wrong direction through the tube are multiple spark-gaps in series and in parallel. They are more or less efficient.

Of interrupters it may be said that the Wehnelt interrupter is still in common use, and that the Caldwell interrupter has been developed by Dr. Caldwell into a more efficient device. Larger quantities of electrical energy may be passed through the primary by increasing the number of holes in the porcelain jar. (See Vol. I, the X-rays in Surgical Diagnosis.)

An efficient device is the use of a transformer in the primary circuit, such that, as stated, the waves all occur in the same direction. With this apparatus either the direct or the indirect current may be used, and by the use of step-up transformers the primary current may be raised to a very high voltage indeed.

The compression diaphragm is used by a certain proportion of X-ray operators, and by others its use is omitted. A comparison of the pictures taken with and without the compression diaphragm has not convinced me that its use is of very great advantage, except to keep the part quiet.

For the greater safety of the X-ray operator and his patients, it is now customary to inclose the tube itself and even the coil in metal or metal-lined boxes. At one side of the tube a window is left, through which the X-rays emerge. Devices have also been used whereby the anticathode is surrounded by metal or glass within the tube itself, leaving only a small window for the emergence of the rays. Still, with all these devices, X-ray burns occasionally occur, and the hands of X-ray operators, unless they are extraordinarily careful, are likely to become the seat of a chronic dermatitis of a threatening character, as already described.

The use of the X-rays has during the past few years come to be more and more in the hands of specialists. As the apparatus has been improved, so has its cost been greatly increased, and, moreover, for the production of good X-ray pictures a large amount of practice and skill are necessary. The average surgeon no longer attempts to take X-ray pictures himself.

A device sometimes very useful in tracing the course of the ureters, and notably in cases where the ureter or its pelvis is dilated, and for the demonstration of these conditions by means of the X-rays, is to inject the ureter through a ureteral catheter with a strong solution of *argyrol*. An X-ray picture is then taken with the solution *in situ*, and the outlines of the ureter and pelvis are clearly shown in the X-ray picture. The device is a very successful one. By feeding patients a quantity of bismuth mixed with starchy food, rice, potatoes, etc., it is possible to take X-ray pictures showing the outlines of the stomach, the presence of pyloric narrowing, hour-glass stomach, etc. Enemata containing bismuth allow the outline of the colon, the presence of strictures, etc., to be demonstrated.

A large number of mechanical improvements have been made in the X-ray apparatus itself and in the accessory apparatus—namely, in X-ray tables, in devices for the production of stereoscopic X-ray pictures and also in methods of viewing the same. The devices relating to tables are mechanical arrangements, such that the patient may be supported quietly in comfortable positions; and, further, devices which permit tilting of the table and of the part which it supports with reference to the plane of the anticathode, and consequently to the line of direction of the rays. This oblique illumination is useful, and even essential, when taking pictures of certain parts of the body, as has already been described in Vol. I.

A very convenient device for taking pictures has been developed by Dr. Caldwell, of this city. The X-ray tube inclosed in a metal box is attached to a framework, and in taking pictures the tube itself is placed beneath the table. Above the table and attached to the same framework is a shelf having a celluloid bottom, or some other material pervious to the rays. This shelf is placed over the part to be pictured. Upon it is laid the X-ray plate inclosed in its envelopes, and above that is a fluorescent screen. The distance of the tube from the plate is readily adjustable, and can be read off from a suitable indicator. The tube and plate can be rotated to any possible angle, or turned over completely, so that the tube is on top and the plate beneath the patient. In addition there is a device whereby stereoscopic pictures may be taken, half the plate being covered during the exposure by a metal plate, and by a clever mechanical device, at the end of the exposure, the other half of the plate is uncovered, the tube is moved in an arc, the center of its circle being at the center of the plate, a suitable distance, and a second exposure is made. These mechanical devices are so cleverly arranged that once the apparatus is set in motion the entire process proceeds mechanically and automatically, including a prearranged time of exposure.

For viewing X-ray pictures, either stereoscopic or other, Dr. Caldwell has constructed a very ingenious cabinet. The interior of the cabinet has as a back wall a dead white surface; numerous electric lights are arranged so that while no direct rays are visible from the front of the cabinet, the dead white surface at its back is intensely illuminated. This illumination may be varied in intensity, and even in direction to some extent by switching on suitably arranged series of banks of incandescent lights. The X-ray plates to be inspected are placed at the front of the cabinet, and movable horizontal and vertical curtains are adjusted in such a manner that all light is cut off except such as comes through the plates. The device exceeds in efficiency any other within my knowledge for the inspection of X-ray negatives. The reflection from the back of the cabinet is diffuse and brings out the details of the negatives with great clearness. In case the negatives are stereoscopic, they are placed side by side in front of the cabinet and viewed by a small hand stereoscope. This stereoscope, a modification of one of Wheatstone's devices, consists of two right-angled glass prisms held in a suitable frame. The prisms

are adjustable for the pupillary distance of the examiner, and are capable also of a rotation upon a vertical axis. The light from each X-ray negative strikes its prism in such a manner that it is refracted toward the outside surface of the prism, whence it is totally reflected to the surface, which is opposite to the eye of the observer. The light rays from the prisms emerge to the eyes practically parallel. The arrangement is such that the double image, always evident when the Wheatstone stereoscope consists of glass mirrors, is avoided; there reaches the eye only one set of light rays. The images of the two plates are combined by the brain so that a stereoscopic picture results. The apparatus is, of course, far less cumbersome than an ordinary Wheatstone stereoscope. Whether the optical results are better or worse, I am not prepared to say. They are certainly satisfactory.

The expense of these very elaborate forms of X-ray apparatus is so great as to be prohibitory except for a specialist or in a large hospital, and while exceedingly convenient, good results may be obtained with apparatus of less elaborate construction.

THE TECHNIC OF THE MICROSCOPIC EXAMINATION FOR THE DETECTION OF THE SPIROCHÆTA PALLIDA OF SYPHILIS

Since the chapter on Syphilis in Vol. I was written, a simpler and better method has been devised for the identification of the spiral organism believed to be the cause of syphilis. The spirochæta has been cultivated in artificial media, and its occurrence is so constant in the various lesions of syphilis not only in the discharges from the primary sore and in secondary lesions, but also in smaller numbers in the tertiary lesions of the disease that it seems at least highly probable that the cause of syphilis has finally been discovered.

The method now in use for examining the organism in the most satisfactory manner is known as the dark-field illumination method. Although discovered in 1837 by the Rev. J. B. Reade in England, and used more or less extensively by microscopists ever since, the great value of this means of illumination for the detection of feebly refractive bodies of small size under the microscope has only recently been appreciated. The principle is much the same as that which renders visible the minute particles of dust in the air against a dark background when illuminated by a ray of sunlight.

The condenser used for this method of illumination differs from the Abbe condenser in that the object to be examined is illuminated by indirect reflected rays which are admitted round a central diaphragm and cast upon the object to be examined. The diaphragm serves as the dark background, in front of which the illuminated matter under examination is perceived with great clearness. The condenser is procurable from manufacturers of microscopes, and may be attached to any microscopic stage. A very powerful source of light is necessary, such as a Welsbach gas lamp furnishing a candle power of from 100 to 125, or a direct current incandescent lamp (Nernst) giving from 150

to 160 candle power. The technic of the examination is as follows: A portion of it is quoted from an article by Willard J. Stone, in the *Journal of the American Medical Association*, March 20, 1909, page 960, *et seq.* If the secretion from a primary sore is to be examined, its surface may be cleansed with a pledget of cotton, and a little of the serous discharge which escapes as a result of the irritation is caught upon a platinum wire loop or with a small curette. Upon a microscope slide a drop of normal warm salt solution is placed.

The secretion obtained by curette or wire is mixed with the drop and a clean cover-glass inverted over it. Or one of the enlarged inguinal glands is seized between the fingers and its center punctured with a hypodermic syringe, through which a drop or two of gland juice is aspirated. A smear is prepared in much the same way from a mucous patch, bulla or condyloma latum. A drop of cedar oil is interposed between slide and condenser, not between cover-glass and lens. The No. 7 Leitz dry objective with No. 3 ocular, or, as I have found best in my work, the No. 8 or No. 12 compensating ocular is used. The No. 7 objective with compensating ocular No. 12 or No. 18, while requiring more intense illumination, gives better results, since the size of the organism is at least doubled, i. e., a magnification equal to a combination of $\frac{1}{12}$ oil immersion and No. 3 ocular. If the oil immersion $\frac{1}{12}$ is to be used with the dark field condenser the lens should be returned to the manufacturer to be fitted with a diaphragm which has been found necessary for this work.

The Spirochætes if present are seen as illuminated spiral-like organisms moving in wavelike motion across the field. In some preparations they are very abundant, while in others some search is necessary to find them. A little practice will serve in differentiating the pale spirochæte from other organisms present in the specimen. In mouth lesions, tonsillar plaques and tongue fissures one must differentiate it from the Spirochæta buccalis and Spirochæta dentium. In fresh smears kept warm by allowing a little warm salt solution to flow under the edge of the cover-glass from time to time, the motility of all these forms can be preserved for an hour or two. As a rule, however, the Spirochæta pallida loses its power of locomotion sooner than the others.

In a fresh specimen the organism is active, the spiral windings very thin and sharp, well differentiated and regular. The flagellum at the end of the Spirochæta pallida is very thin in proportion to the thickness of the body, while the end of the body is thicker than in most of the other forms. The flagellum is also longer, as a rule, than in other forms. The characteristic spiral movement of the Spirochæta pallida is forward and backward, and when it attaches itself to a leucocyte it remains quiet often for a considerable time, even in fresh preparations. Hoffmann has stated that the other forms attach themselves less often to cells present in the smears. At times the Spirochæta pallida has a distinct sideways pendulum movement. It is more feebly refractive than the other forms commonly found and the windings or spirals are more acutely bent. The other spirochætes encountered most commonly are Spirochæta balanitidis and Spirochæta refringens.

Stone points out, that if pains are taken to cleanse the lesion with a pledget of cotton wound on an applicator before obtaining the material on a sterile

wire, and especially if the lesion is irritated with the wire after such cleansing so as to secure an exudation of "irritation serum" from the deeper layers of tissue, the commoner forms of spirochætes are less seldom observed. For the differences in characters of other forms of spirochætes, see Vol. I, Syphilis.

In the diagnosis of early syphilitic lesions, it is to be remembered that a positive finding is more valuable than a negative one. It seems probable that, inasmuch as the primary seat of infection is the area in which the spirochætes develop during the earlier weeks of the disease in largest number, that very early excision of the initial lesion may have some effect in limiting the number of microörganisms early entering the blood. A positive diagnosis having been made, we are, it is now believed, justified in bringing the patients under the influence of mercury at once. It may, however, be here reiterated that *considerable experience* is necessary in order that the opinion of the observer as to the presence or absence of the Spirochæta pallida may be valuable.

The primary lesion of syphilis requires, as stated in Vol. I, on the average twenty-one days for its development. Recent investigations, however, show that during this period the microörganisms are already being diffused throughout the entire body. Nevertheless, experience shows that if active treatment is commenced soon after the appearance of the initial lesion, upon the finding of the spirochæta, the more serious subsequent lesions of the disease are frequently avoided.

ACUTE RHEUMATIC FEVER

The most recent investigations in regard to the nature and causation of acute rheumatic fever—i. e., acute polyarticular rheumatism and its complications, indicate that the disease is a septicemia with, in many instances, multiple localizations in the joints. This conclusion is, of course, not new, but at present it seems to rest upon a sound basis of pathological observation and experience.

The microörganism causing the disease is a *streptococcus*, indistinguishable by any means from the streptococci causing erysipelas, abscess, phlegmonous inflammations, etc.

The most common portal of entry is the tonsil, though the organism may also be invaded from the intestine. For further details, see "The Pathology of Acute Rheumatic Fever," J. C. Meakins, *Medical and Surgical Report of the Presbyterian Hospital in the City of New York*, 1908, page 159 *et seq.*

EXOPHTHALMIC GOITER AND HYPERTHYROIDISM

A few additional data are here given concerning the pathology, symptoms, and diagnosis of exophthalmic goiter. One of the most important facts for the surgeon to bear in mind is that other forms of thyroid enlargement, whether cystic or other, may be associated on the one hand with exophthalmic goiter, or on the other with hypothyroidism, and in undertaking operations for enlarge-

ments of the thyroid the surgeon should always bear this in mind, since in cases of hypothyroidism, while there may be an indication for the removal of a cystic or other tumor of the thyroid, the removal of what remains of an already imperfectly functionating gland may be attended by disastrous results.

Among all the investigators in this field, the work of Moebius has been as important as any. (See P. J. Moebius, "Die Basedow'sche Krankheit," 2d ed., Wien, 1906, quoted by George Dock, "Osler's Modern Medicine," Vol. VI, page 415 *et seq.*) In that paper Moebius says:

> Basedow's disease is an intoxication due to the morbid function of the thyroid gland. If it is true that toxic substances are found in the body which are neutralized by the thyroid secretion in the circulation or in the gland itself, Basedow's disease can be looked upon as a "hyperthyroidization," . . . everything points to a primary disease of the gland, but in this case we must assume more than a hyperthyroidization, the causes not only too much, but also poor secretion.

Moebius believes that the morbid products produced by the gland in exophthalmic goiter act upon the heart and the blood-vessels, the central nervous system and the skin. The exophthalmos he ascribed to the local alteration of the blood-vessels. The poison acts not only upon the cortex of the brain, but also upon certain of the cerebral nuclei.

The changes in the thyroid vary in degree within wide limits, so that great variations in the severity of the symptoms produced are observed in different cases. Thus, the cases may be acute or chronic, there may be remissions and exacerbations, and the disease may be followed by death, or in other cases by almost complete recovery. In the slightest cases the symptoms are few and not marked, so that a positive diagnosis of the condition may be difficult. In a certain proportion of cases the primary enlargement of the thyroid is followed by atrophy, with the production of the symptoms of myxedema. Moebius[1] says:

> In myxedema the thyroid is small, in Basedow's disease large; in the former the circulation is sluggish, in the latter accelerated; in the former the skin is cold, dry, and thick (with mucin), in the latter thin, warm, and with unusual sweating; in the former the mind is sluggish, in the latter weak and irritable.

Symptoms almost identical with exophthalmic goiter may be produced by the internal administration of large doses of thyroid extract in normal cases. The symptom exophthalmos is, however, absent in all but a very small proportion of these cases. As was stated in Vol. I, the four characteristic signs and symptoms of exophthalmic goiter are as follows:

I. Enlargement of the thyroid gland, often slight or moderate in degree, with increased vascularity of the organ.

II. An irritable and rapid heart (tachycardia). Very large goiters of other kinds may produce a rapid and laboring heart, notably when they extend

[1] "Die Basedow'sche Krankheit," Wien, 1906.

downward into the thorax and cause dyspnea by pressure upon the trachea or interfere with the return of blood to the heart by pressure upon the veins. These two types of disordered heart action should be distinguished one from the other, and this can usually be done with ease.

III. Tremor. A fine, rapid tremor, most marked in the fingers and hands and best seen when the fingers are outstretched, is an early symptom. In bad cases it may extend to all four extremities and be accompanied by marked muscular weakness.

IV. Exophthalmos. Protrusion of the eyeballs.

These signs and symptoms are usually all present in marked cases, and when present the diagnosis admits of no question. It is to be borne in mind, however, that even in marked cases any one of these signs may be absent, and in early cases none of them may be marked. Of all the signs the protrusion of the eyeballs is probably the most constant.

A variety of confirmatory eye symptoms have been recorded by different observers. They are eleven in number, and I think it best to enumerate them for the sake of completeness. They have been categorically arranged by A. McGlannan: [1]

I. (v. Graefe.) The upper lid does not follow the eyeball in looking downward.

II. (Dalrymple v. Stellwag.) The upper lid is retracted in straightforward vision, so that the sclera becomes visible above the cornea.

III. (v. Stellwag.) Infrequent and incomplete involuntary winking.

IV. (Moebius.) Inability to hold the eyes in convergence.

V. (Gifford.) Difficulty in everting the upper lid.

VI. (Jellinek and Rosen.) Pigmentation of the upper lids.

VII. (Joffroy.) The forehead does not wrinkle on looking up.

VIII. Epiphora.

IX. Tremor of the eyeballs.

X. (A. Kocher.) Sensation of pressure behind the eyes.

XI. Abnormal dryness of the eyes.

Pathology

The pathological changes in the thyroids of Basedow's disease have been very carefully worked out by MacCallum. The following details are quoted from his more recent work.[2]

The thyroid is enlarged, although, as a rule, not to a great size; in some cases it is not larger than the normal, or it may be actually decreased in size. At operation the superficial veins are found to be very large and easily torn and are distended with blood, so that the gland has a very congested appearance. This is not striking in the excised portion, since the vessels collapse, and on section the interior of the gland tissue is rather pale. Usually the tissue is hard and rather rigid than elastic. Its normal amber red translucence gives way to a grayish opacity, and the

[1] "Review in Surgery," *Maryland Medical Journal*, April, 1909.

[2] *Journal of the American Medical Association*, October 5, 1907, p. 1158.

fresh cut surface, instead of being glairy or gelatinous in appearance, tends to be rather dry and granular. This varies with the amount of colloid material in the alveoli, and in many advanced cases the cut surface may be still moist and give off a little glutinous material. The surface of the gland is usually somewhat nodular and rough, and this is seen to be true also of the surface, in which it is found that fine strands of fibrous tissue traverse the glandular substance, separating it into lobules.

Usually the change is diffuse throughout the whole gland, but sometimes one lobe may be much larger than the other, and in some cases the alterations described are present only in small patches here and there throughout a gland which otherwise seems normal. These foci are easily distinguished by their fine grain and by their opacity, from the adjacent colloid holding tissue.

Microscopically there is found the change which appears in experimental compensatory hypertrophy (such as Horsley and Halsted found in partial thyroidectomy). Strands of fibrous tissue run in every direction like scars through the gland and separate the tissue into lobular masses, and in these lobules the alveoli are often separated by a fibrous tissue stroma much more abundant than in the normal gland. The alveoli are no longer rounded, full of colloid, and lined with low, cubical epithelium, but are extremely irregular in size and in form. As a rule, most of them are smaller than normal, while in the central part of each small lobule there are larger alveoli of very irregular outline, sending out diverticuli in every direction and encroached on by epithelial projections which extend into their lumen. With some special methods of staining the connective tissue it may often be made clear that such a small lobule is probably a sort of colony in which the smaller peripheral alveoli are derived from the more centrally placed, or are actually merely sections of the diverticula of the central ramifying alveolus. This alternation of large, irregular alveoli with small ones ranged around them is very characteristic, and evidently results, in part, at least, from the separation of portions of the central cavity in the form of new alveoli.

The epithelium becomes columnar not only in the large alveoli, but in the small ones as well, and thus occupies so much space that there is but little lumen left. Indeed, the areas occupied by the small alveoli may appear almost solid, so small are their cavities and so scant the colloid. In most instances the epithelium is very regular in its form throughout, and the details of its structure can be made out very clearly. The cells are plump, with a finely granular protoplasm and a sharp outline. The free surface is very sharply marked and is sometimes slightly dome-shaped. The nucleus may lie near the base or near the free end of the cell. Mitotic figures are frequently to be found. Occasionally some of the cells appear narrow and shrunken and biconcave in form, with a very deeply stained nucleus and dark-red protoplasm. These are the so-called colloid cells of Langendorff, thought by him to be especially concerned in the secretion of colloid, but which seem rather more like the result of some degenerative process. Only rarely could the so-called *Schmelzepithel* of Huerthle be seen, and then it seemed obvious that it was the effect of mechanical dislodgment and disarrangement of the cells. Similarly the extensive desquamation of the epithelial cells which one so often sees in specimens removed at operation seems to be due to the considerable pinching and handling through which the specimen unavoidably passes during the operation. Nevertheless, we have met with one or two cases in which, in association with espe-

cially severe symptoms, there has been found widespread desquamation of the epithelium, probably not the result of pinching the gland, and this is regarded by some, especially by Dr. Bloodgood, as a feature associated particularly with very severe symptoms.

In these extreme cases peculiar alterations of the epithelial cells are sometimes found. In several instances we have observed areas in which the epithelium was enormously swollen so as to practically obliterate the lumen of the alveolus. These large, irregular cells no longer preserve the columnar form, but are shapeless masses of finely granular protoplasm which takes an intense pink stain with eosin and in which the nuclei are also irregular in form and size and stain very deeply, almost black, with hematoxylin. Usually one or two alveoli only show such a change in their epithelium, or there may be only a few cells of this form intercalated among others of the usual type in the alveolar wall, but sometimes over considerable areas all the alveoli are packed with such cells. Their significance is far from clear. Much more frequently there are found cells among the ordinary epithelial cells of the alveolar wall which are greatly enlarged, but the protoplasm of which retains the characters seen in the rest of the cells and contains only a scant basophilic granulation. The nuclei of such cells are usually much enlarged and vesicular, with scattered chromatin granules.

The colloid varies greatly in different cases, but it seems that in most of the more severe cases it is markedly diminished in amount and altered in quality, the normal hyaline material being replaced by a very palely staining substance or by a ragged, shreddy, granular, or vacuolated mass which has no longer the refractive qualities of the normal colloid. There are some cases, however, in which there is a great deal of fairly normal looking colloid, and this is especially true of those instances in which the hypertrophy of the epithelium is relatively slight; cases, that is, in which the process is apparently advanced, at least so far as the thyroid is concerned. On the other hand, when the colloid is greatly diminished one rarely fails to find severe symptoms, and when the symptoms are very indefinite or in part absent it is usual to find a good deal of colloid.

The most interesting cases are those in which intense symptoms exist, but in which at the same time the alveoli contain a large amount of colloid. There are at least twelve of these cases in our series, and although in some of them one may explain the existence of such large alveoli full of colloid, on the idea that the exophthalmic symptoms are associated with changes which have appeared in a gland already the seat of alterations such as are seen in a colloid goiter, still, there remain many in which there is no evidence of such a previous goitrous change. From this it appears that the presence of quite abundant colloid is not inconsistent with the development of intense symptoms, although in most cases in which the symptoms are intense the colloid tends to disappear with the advance in the alterations in the gland. It is not improbable that the amount of colloid may bear a fairly constant relation to the stage of progress of the disease, and light may be thrown on this by the consideration of the tissues removed at successive operations. One can distinguish, however, different types of change in the thyroid in different cases, for while in one group the alveoli are not larger than normal, show elevation and folding of the epithelium, and are full of colloid, another group with quite as intense symptoms will present thyroid tissue composed of very large alveoli full of colloid in which, nevertheless, the folding of the epithelial layer is most compli-

cated. A third group comprises cases usually milder in their course in which the alveoli are large and full of colloid, but in which the alveolar epithelium is almost flat, except in certain foci or in portions of some of the alveolar walls, where it becomes cylindrical and thrown up into folds. Several cases in which extirpation of the thyroid was carried out with good results for the relief of indefinite symptoms, such as the combination of goiter with tremor only, or with moderate tachycardia only, showed in the thyroid abundant colloid in large alveoli which are hardly at all irregular, but nevertheless in places show areas of epithelium which has become high and cylindrical and which is beginning to project prominently into the alveolar lumen.

Finally, in a few cases in which the symptoms were reduced to nervousness or slight tremor with goiter, the excised tissue shows the normal structure or that of a circumscribed adenoma.

The focal nature of the alterations in the thyroid is especially interesting, and may be recognized in some cases in the fresh cut surface of the gland by the opacity and granular surface of the altered areas which contrast with the surrounding tissue. Apparently this, too, represents a stage in the development of the lesion, and in most of the six cases which show it the symptoms had existed only a short time before the operation. Microscopically the altered areas are quite sharply demarcated from the rest and may involve a great number of alveoli, or be limited to very small foci, including only a few alveoli here and there.

In sixteen cases there were found, on cutting through the thyroid, rounded, circumscribed nodules which projected above the general level and differed in consistence and general appearance from the rest of the gland. These are the adenomatous nodules which constitute a considerable proportion of ordinary goiter, and hence they are by no means peculiar nor characteristic of the changes in exophthalmic goiter. They are most commonly finely granular and opaque, occasionally flecked with yellow patches of necrosis or with hemorrhages, and on section they are seen to be composed of small, round alveoli lying quite separate from one another in an abundant loose stroma and lined with cubical epithelium. In only a few cases did the alveoli which make up such embedded nodules show the folding and other hypertrophic changes which characterize the tissue round about, but in one case in which exophthalmic symptoms were well marked these changes were limited to the tissue forming such a circumscribed nodule. In another case the hypertrophied tissue was found to form the thick lining of a cyst.

The second type of circumscribed nodule is that which is composed of a tissue very rich in colloid and correspondingly translucent. The central part is often occupied by a cystlike cavity filled with a greenish, glutinous fluid. Such nodules show microscopically very large alveoli more or less radially arranged and distended with colloid. The amount of fibrous tissue traversing the gland varies in different cases, sometimes occurring in coarse bands that separate the tissue into lobules, while in other cases there are, in addition, fibers which separate the individual alveoli.

In six it was possible to study the thyroid at different stages in the progress of the disease, either in tissue removed at two different operations or at autopsy in patients who died some time after the operation. No very constant results were obtained. In four of the cases in which the intervals between the times of obtaining the two specimens were seven months, eighteen months, forty-five days, and

seventy-nine days, the tissues were practically identical in the two portions examined. In the fifth case, after a lapse of nine months, the tissue from the second operation showed that the epithelial cells had become greatly increased in height and the colloid rather more abundant. In the case in which the longest interval elapsed between the operations, two years and six months, the alveoli had changed from small, compact, almost solid masses of epithelium, with inconspicuous lumen and no colloid, to large ramifying spaces full of ragged colloid and lined with very high cylindrical epithelium.

Other changes are observed in various structures and organs in cases of exophthalmic goiter.

The Lymphatic System.—In the thyroid gland there are often observed increased quantities of lymphoid tissue. Such may occur in larger or smaller masses scattered throughout the substance of the gland. The lymph nodes of the neck as well as the mediastinal and mesenteric lymph nodes and others may be enlarged.

Spleen.—The spleen is often enlarged, but exhibits no characteristic pathological changes. Enlargements of the thymus gland also are observed.

Sympathetic System.—Various degenerative changes have been observed in the ganglia and nerves of the sympathetic system. They are not believed to be characteristic nor essential lesions.

The Central Nervous System.—Degenerative changes in the form of atrophy, minute hemorrhages, etc., in various parts of the central nervous system have been observed in fatal cases of exophthalmic goiter. They have not been shown to bear any constant relation to the disease.

The Muscles.—Muscular weakness is one of the most marked and constant accompaniments of exophthalmic goiter, and M. Askanazy [1] reported atrophy and fatty degeneration of muscle fibers affecting the muscles of the abdomen, pelvis, eyes, tongue, and thorax in cases of exophthalmic goiter.

Iodin.—The thyroids of exophthalmic goiter are found to be poor in iodin. In some cases iodin is almost absent from such glands. In others the quantity of iodin is normal, or even increased. The iodin of the thyroid is contained in the colloid material of the gland, and its presence or absence in the general circulation probably depends upon whether or not such iodin remains fixed in the colloid material, so that it cannot enter the circulation, or whether, on the other hand, the conditions of its existence admit of such entrance into the blood.

The Blood.—There are no very definite changes observed in the blood. A simple anemia of moderate degree is usually present. In other cases chlorosis. The polymorphonuclear cells are usually diminished in number, while a relative or absolute increase of lymphocytes is common. It may be absent even in severe cases, though Kocher considers that the increase in lymphocytes is proportionate to the severity of the disease.

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[1] *Deut. Arch. f. klin. Med.*, 1898, Band LXI.

The Symptoms of Exophthalmic Goiter in Detail

The Thyroid Gland.—As already stated, exophthalmic goiter may occur in thyroids already the seat of one or other form of disease—cystic, colloid, or other. In these cases the enlargement of the thyroid will usually be asymmetrical and the physical characters of the disease already present will determine the size, shape, and consistence of the thyroid tumor. Thus, in cases of exophthalmos we may find the gland unilaterally enlarged and the seat of fibrous degeneration, or of a cystic or adenomatous tumor in one or other lateral lobe.

The onset of the disease may be sudden or gradual, and the symptoms may rapidly develop up to a certain point and then become stationary, to be followed by remissions or exacerbations. In a small proportion of cases no notable enlargement of the thyroid gland can be detected.

In a good many cases the enlargement of the thyroid is slight, in others moderate, in others very marked indeed. When no cyst or tumor of the thyroid exists, the enlargement is commonly symmetrical. The consistence of the gland varies a good deal in different cases; it may be soft, firm, and elastic, or very rarely quite hard. Upon auscultation over the tumor a systolic murmur is commonly heard which may be soft and blowing or quite high pitched. In other cases the murmur is continuous. In some cases there will be a murmur all the time; in others the presence of the murmur is inconstant. Pressure symptoms as the result of pure exophthalmic goiter are rare.

Disturbances of Circulation.—One of the most constant phenomena of the disease is palpitation of the heart. In the earliest stages such increased heart action is commonly observed only after physical exertion or emotional excitement. Such palpitation may be accompanied by the subjective sensation of choking or suffocation. An increased rapidity of pulse-rate (tachycardia) is a more constant symptom even than palpitation of the heart. The heart beats are increased in frequency to 90, 100, 120, or even 150, per minute. During the more severe attacks of toxemia, extremely rapid pulse-rates are observed, so that the pulse can scarcely be counted. In the cases which are fatal, hypertrophy of the ventricles of the heart, notably of the left ventricle, is commonly observed. During the more severe attacks, upon placing the hand on the precordium the heart may be felt beating violently against the chest wall. The apex-beat may or may not be displaced to the left. The heart dullness is increased, also to the left. Heart murmurs may or may not be present, and such murmurs may be transmitted to distant portions of the chest wall. The pulsation of all the arteries of the body is apt to be excessive, and the pulsations of the carotids and of the abdominal aorta may be so marked as to be a constant source of annoyance to the patient. Irregularity of the heart action is a common symptom.

The Eyes.—Protrusion of the eyeballs is present in about three quarters of the cases of exophthalmic goiter. It may appear early in the disease or be long delayed. It varies also much in degree, from a scarcely perceptible bulging

to a very marked prominence of the eyeballs. It does not appear to bear any definite relation to the severity of the general symptoms, or to the size of the goiter. The exact cause of the protrusion is not definitely known. The exophthalmos may be associated with a feeling of tension in the eyes, sometimes with pain. Usually the pupils show no definite abnormalities. The other more or less characteristic eye symptoms have already been noted in the beginning of this section.

The Nervous System.—A marked increase of nervous excitability is one of the regular symptoms of exophthalmic goiter. The patients are often neurasthenic. They are easily fatigued and become unduly excited from slight sources of irritation. There may be more or less marked confusion of mind or loss of memory. In a few cases there appears to be an increased cerebral activity, so that these patients may be capable of doing an unusual amount of mental work. Conditions of mental depression and exaltation are not uncommon and usually alternate. In the most severe cases there may be marked mental symptoms, such as acute mania with hallucinations and profound confusion of mind. In other cases the patients fall into an apathetic or stuporous condition. In some of these cases the mania may reach a severe grade with suicidal or homicidal impulses.

Subjective sensations of heat and cold or other paresthesiæ may be felt in the extremities. There may be neuralgias in various regions, and cramps in the voluntary muscles of the extremities. The patients usually do not sleep well. There is in many instances an increase of tendon reflexes. A complicating peripheral neuritis is occasionally observed.

Muscles.—As already mentioned, a fine, rapid, rhythmic tremor is commonly observed in the hands. This is one of the regular symptoms of the disease and is rarely absent. There is general muscular weakness of a fairly marked character involving all the voluntary muscles. Occasionally atrophy of individual muscles or groups of muscles is observed—the muscles of the forearm, or of the leg, or of the neck. In a few cases there is gradually developed paraplegia. In other cases hemiplegia, and in still others paralysis of one extremity.

The Skin.—In many instances excessive sweating occurs, notably of the hands and face. In many instances the skin of the face is more or less constantly flushed; in others it may be pale, although the content of hemoglobin in the blood be normal or nearly so. Edema of the extremities is occasionally observed, and circumscribed areas of edema and of urticaria are not uncommon. In a certain proportion of cases there is an increased deposit of pigment in the skin, so that these patients have the appearance of moderate sunburn. It is not, however, confined to the face, but may appear on other parts of the body, notably where a considerable quantity of pigment normally exists. A symptom of the disease was noted by David Walsh:[1] "He found that there

[1] Proceedings of the Royal Society of Medicine, May, 1908, p. 195.

was a band of baldness developed across the frontal region with prolongations running back from either end thereof." In some cases the eyebrows and eyelashes are lost. The body hair may also fall out, and premature grayness of the hair is not uncommon.

The Alimentary Canal.—The appetite is usually preserved and may be increased. The patients are often abnormally thirsty. In other cases the appetite is diminished or lost. *Vomiting* is an occasional symptom. *Diarrhea* occurs in about one third of the cases and may be continuous, or occur in marked attacks. The diarrhea may be accompanied by abdominal pain with watery stools, and may be so severe as to produce profound exhaustion. The diarrhea may come on suddenly and last for several days in spite of treatment, and cease as suddenly as it began. It may be a very early symptom of the disease, even before the enlargement of the thyroid. In some cases it appears to be an important element in a fatal result.

Dyspnea.—Dyspnea is not an uncommon symptom. It may be accompanied by cough, hoarseness, and aphonia.

The Urine.—The excretion of nitrogen—i. e., urea and uric acid—is increased, and the same is true of the phosphates. Albuminuria and casts, usually of the hyaline variety, may be present. The urine may be increased in quantity and may contain sugar. True diabetes is an occasional complication.

Emaciation.—Marked loss of weight is one of the regular accompaniments of the disease, and such loss may be very marked indeed, amounting in some cases to more than a third of the body weight. The emaciation is increased by vomiting and diarrhea, but may occur independently of either.

Fever.—Fever occurring in irregular attacks is an occasional symptom of the disease, and is most often observed in the fatal cases. The fever is of an irregular septic type, sometimes remittent, sometimes intermittent. It may come on in attacks lasting several days or several weeks. It is apparently due in many cases to the absorption of toxic materials, owing to the faulty action of the thyroid gland.

Complications.—The complications of exophthalmic goiter are many and varied. I shall merely enumerate the more common lesions. Chlorosis, pseudoleukemia, pernicious anemia, fatty degeneration of the liver, hysteria, epilepsy, paralysis agitans, tabes, tuberculosis. Myxedema may occasionally follow exophthalmic goiter, probably as the result of atrophy of the diseased gland.

OPERATIVE INDICATIONS IN BENIGN DISEASES OF THE STOMACH

Since the section in Vol. II was written relating to benign diseases of the stomach, the views of surgeons in regard to the operative treatment of these conditions have undergone certain modifications, the result of a more extended experience and better understanding of the pathology of these conditions. The operation of posterior gastroenterostomy, while still performed with excellent results in a large number of benign diseases of the stomach, is not regarded at the

present moment as a universal panacea for these conditions. Its usefulness at the present time is restricted to the cases in which actual pyloric narrowing exists *without evidences of present or threatening malignant disease.* It has come to be better understood that the stomach is not a mere bag or receptacle in which food lies more or less quiescent for a certain time, but that *the stomach is a muscular organ, and that the action of its walls is to force the food swallowed through the pylorus and into the duodenum.* In the presence of an ulcer in the vicinity of the pylorus and where no pyloric obstruction exists, if the operation of gastroenterostomy be performed, the food will tend to travel as before in the direction of and through the pylorus, and not to seek the new and artificial channel. The artificial opening, on the other hand, will tend to close of itself and the patient will not necessarily be in any way benefited. I do not think that I can do better than to state the conclusions of W. J. Mayo in regard to the work of himself and of his brother in the operative treatment of gastric and duodenal ulcers. The conclusions given are based upon observations made during a number of years of very active work in this field.[1]

The third period covers about two and a half years. The doubtful cases have been eliminated and a living pathology established which enables the surgeon to recognize the ulcer at the operating table. If the ulcer is not actually demonstrated no gastric operation is undertaken unless necessitated by hemorrhage.

Gastrojejunostomy is still our most valuable operation especially for duodenal ulcer, which is the lesion in nearly two thirds of our cases.

The operation of Finney is chosen for pyloric strictures (Finney's Gastroduodenostomy).

Ulcers in the stomach at a distance from the pylorus are excised.

If hour-glass contraction is present, the whole diseased area is excised. If it is not possible to do this, proximal gastrojejunostomy is performed.

Calloused ulcer of the pyloric end of the stomach indicates the operation of Rodman, consisting of resection of the diseased area with closure of the duodenum and independent gastrojejunostomy.

The mortality of even the more complicated operations does not exceed 3 per cent, while the cures will, I believe, run 95 per cent, or over.

At the same meeting of the American Surgical Association a paper was read by B. J. A. Moynihan, of Leeds, England:[2]

The conclusions of Moynihan drawn from the study of his own cases were at that time as follows:

1. The operative treatment of stomach disorders should be confined exclusively to those cases in which an organic lesion is present. Unless there is a palpable and demonstrable ulcer in the stomach or in the duodenum, or some condition which hampers the proper action of the stomach, the symptoms are not due to any patho-

[1] Proceedings of the American Surgical Association, vol. xxvi, 1908, p. 142 *et seq.*

[2] *Ibid.*, p. 139 *et seq.*, Moynihan, "Late Results After Operations for Benign Diseases of the Stomach and Duodenum."

logical cause capable of being relieved by surgical interference. However careful our preliminary investigations may be, we shall, from time to time, display upon the operating table a perfectly normal stomach. We must not then endeavor to cover our diagnostic disaster by the performance of an unnecessary operation upon the stomach, but rather must we candidly confess that our exploration has proved negative. To perform gastroexterostomy in such cases has, I think, been proved to lead to unsatisfactory results, whereby the operation is discredited.

2. In cases of acute perforating ulcer the perforation should be closed or the ulcer excised. When the ulcer lies upon the lesser curvature nothing more is necessary than this. The after-history of such cases shows that they are relieved from all disabilities referable to the stomach. When the ulcer is prepyloric, pyloric or duodenal, gastroenterostomy also should be performed. It doubtless hastens the immediate recovery of the patient by affording an easier exit from the stomach than that impeded by the ulcer, and it forestalls the almost certain onset of symptoms which only a short circulating operation can relieve.

3. When a nonmalignant lesion is discovered, the treatment appropriate to it depends upon its position in the stomach. If an ulcer be placed on the lesser curvature at some distance from the pylorus, in such a position that no obstruction is offered to the onward passage of the food, excision should be performed. In such cases the relief from gastroenterostomy may be incomplete, and it is probable that the later onset of malignant disease occurs in a large proportion of cases. In some cases, however, when the ulcer is on the curvature or on the posterior surface of the stomach adherent to the pancreas, relief follows if gastroenterostomy is performed on the cardiac side of the lesion. It may be that the ulcer when anchored impedes the proper movements of the stomach, or that the nerve supply being interfered with, some local paresis of the gastric wall results.

4. If the ulcer be prepyloric, pyloric, or duodenal gastroenterostomy should be performed. It is desirable also to infold an ulcer whenever possible, for both hemorrhage and perforation have occurred from ulcers for which gastroenterostomy has been performed months or years before. The local treatment of the ulcer is always desirable, and is generally easily performed.

5. The most satisfactory method of gastroenterostomy is the posterior no-loop operation, with the almost vertical application of the bowel to the stomach. The vertical position is that into which the jejunum falls most easily in the normal (that is the erect) position of the body. A deviation to one or other side if slight is of no importance, and entails no untoward consequences.

6. Regurgitant vomiting occurs as a result of the "loop" operation, whether anterior or posterior. It is relieved almost certainly by an entero-anastomosis. Patients who suffer from it may be relieved entirely of all symptoms for which they originally sought relief. An operation that is mechanically imperfect relieves the original disorder, though it leaves serious disabilities behind it. The vomiting of bile may be relieved by lavage, and in some patients disappears entirely after the lapse of weeks or months or even years.

7. In cases of hour-glass stomach the surgical treatment necessary presents special difficulties on account of the frequency of a dual lesion, one in the body of the stomach, one at the pylorus; and double operations have consequently to be frequently performed.

SOME ADDITIONAL DATA IN REGARD TO THE DIAGNOSIS OF ORGANIC LESIONS OF THE BRAIN

In the following description of the signs and symptoms due to organic lesions of the brain in addition to those given in Vol. I, the author is largely indebted to an article by Harvey Cushing, which appeared in Keen's "Surgery," Vol. III, page 160 *et seq.*

As was stated in Vol. I, organic lesions of the brain produce local and general signs and symptoms of a very varied character. The general symptoms consist of disturbances of the intelligence, of headache, sometimes of giddiness, vomiting, general convulsions, and changes in the appearance of the fundus of the eye. They are not symptoms which permit of a conclusion as to the exact situation of the lesion. For the determination of the site of disturbance in the brain, we are obliged to depend upon groups of symptoms, partly paralytic, partly irritative in character, ordinarily known as focal symptoms.

Headache.—Of the general symptoms accompanying organic disease of the brain, but, of course, by no means confined to these conditions, headache is one of the most frequent. Before we can draw the conclusion that headache is due to organic cerebral disease, it is necessary to exclude a great variety of causes which may produce headache—the various anemias, autointoxications following disturbances of digestion; in females, disorders of the genital apparatus and general constitutional diseases of many kinds. Locally, we are obliged to exclude neuritis of the cranial nerves, localized foci of pyogenic infection in the mouth, the teeth, the mastoid process, the bones of the cranium, etc. Syphilitic gummatous inflammation of the bones of the skull and syphilitic pachymeningitis are regularly attended by continuous or remittent headache of a severe character. The headache of lesions of the brain is believed to be largely due to an increase of intracranial pressure. Only in a moderate number of cases does the localization of the headache point to the site of the intracranial lesion. If, however, headache is complained of over a fixed area, and in addition there is localized tenderness on palpation and percussion of the skull over the same area, it is, in certain instances of abscess, less often in the case of tumors, an aid in the localization of the lesion. In a general way it may be said that severe headache which is continued over a long period is highly suggestive of some form of brain syphilis, or if this can be excluded of some other organic intracranial lesion.

Vomiting.—Vomiting is a very common symptom in intracranial lesions, whether due to injury or disease and whether acute or chronic in character. The characteristic feature of cerebral vomiting is that it occurs *without nausea* in many cases, though in others the symptom of nausea may be present. The so-called projectile vomiting, with or without nausea, is frequently present in intracranial lesions of many kinds, notably those which produce an increase of intracranial pressure.

Giddiness.—Giddiness, or vertigo, is a symptom so common in functional disturbances, as well as in organic disease of the brain that it has no very marked diagnostic significance. It may be associated with disturbances of the auditory nerve, and is a particularly common symptom in lesions of the cerebellum.

Changes in the Fundus of the Eye, Optic Neuritis, "Choked Disk."—The presence of choked disk as determined by ophthalmoscopic examination is a very common objective sign in a great variety of cerebral lesions. It may be slight in degree or be attended by a certain amount of dimness of vision. There is a gradual diminution in size of the visual field, though central vision may remain acute until the lesion is far advanced. In extreme cases blindness occurs.

Convulsions.—Generalized convulsions may be produced by a diffuse or localized lesion of the brain, and may of course occur, notably in children, from various functional disturbances. Only when the convulsions are confined to some particular set of muscles, or begin uniformly in the same limb or part of a limb, do they furnish aid in localizing a brain lesion.

Stupor.—Every possible grade of stupor, from slight drowsiness and lethargy to the most profound coma, may result from local and general functional and organic disturbances of the brain. Stupor or coma may also arise from many forms of toxemia, alcohol, diabetes, for example, or may, on the other hand, be due to disturbances of the entire cerebral circulation.

Disturbances of general health, loss of appetite, emaciation, general muscular weakness, together with changes in the temperature, pulse, and respiration are frequent concomitants of organic brain disease, but possess merely a general diagnostic significance.

Focal Symptoms.—Paralyses of muscles of any possible distribution may result from organic brain lesions. In some cases the distribution of the paralysis is an important aid in the diagnosis of the part of the brain affected. Such paralysis may involve half of the body (hemiplegia), or both lower extremities (paraplegia), or both arms and both legs (diplegia), or but one extremity (monoplegia). The following characters of paralyses resulting from lesions of different portions of the brain are quoted from Cushing:[1]

Paralyses of cortical origin are apt to be accompanied or preceded by irritative symptoms, and are more commonly monoplegic in character. Paralyses of capsular or peduncular origin, since the fibers of the pyramidal tract are gathered there in a small space are more apt to be hemiplegic. The so-called "crossed paralysis" is one in which a cerebral nerve palsy on one side accompanies paralysis of the limbs on the opposite side. Motor paralyses of pontine or medullary origin rarely fail to have accompanying symptoms due to involvement of neighboring structures.

Spasticity of the muscles with increased reflexes, occur as the result of a lesion of the intracranial portion of the motor pathway. Should the lesion take place in

[1] Cushing, *loc. cit.*, p. 163.

the young, there may be marked disturbance of growth. Contractures occur, whereby the limbs become fixed in awkward positions.

Motor irritation is evidenced most frequently by epileptiform seizures or convulsions. Local convulsions in the form of monospasm is a common indication of a lesion at or near the so-called motor area. The process leading to convulsions may be a quiescent one—a cortical defect; the cicatrix of an old healed focus of hemorrhage, etc.—or one which is progressive as an enlarging cyst or tumor. A localized convulsion may be followed by paralysis; a general one, by a condition of profound muscular exhaustion and when frequently repeated and the so-called *status epilepticus* ensues, death may result from asphyxia due to failure of respiratory movements. Other irregularity of movement—ataxic, choreic, athetoid, etc.—are usually the result of lesions in organs like the cerebellum or basal ganglia which modify movements, rather than those affecting the primary conducting path.

On the Sensory Side.—Like those of motion, sensory disturbances may result from cortical or subcortical lesions. They also may be irritative and associated with subjective symptoms of paresthesia or paralytic, and accompanied by anesthesia.

Anesthesia may be complete or partial (hypesthesia) to various forms of stimulation—to pain, touch, pressure, temperature, etc. The deeper, as well as the cutaneous sense, may be affected and there may be loss of the sense of posture in an extremity, or of its position in space. Owing to the fact that a profound sensory paralysis leads to the shutting off of all afferent impulses, a certain degree of motor impairment is an almost invariable accompaniment. On the other hand, no sensory disturbance need accompany motor paralysis.

Irritative sensory symptoms may precede those of motion. Thus, the aura or warning of an impending convulsion may be an important clinical sign and may at times serve to indicate the situation of the lesion, even though the convulsion itself was general from the onset. The warning may occur as a subjective sensory, gustatory, visual, or olfactory impression.

Disturbances of special sense perception may be secondary not only to peripheral lesions of the nerves themselves, but also to lesions of the cerebral centers where special sense impressions are registered. A lesion may pervert or destroy any of the special sense qualities—smell, taste, hearing, and sight.

THE REGIONAL DIAGNOSIS OF BRAIN LESIONS

In a certain proportion of cases it is possible, by means of study of the focal symptoms produced, to determine with more or less accuracy the seat of the lesion, and while a certain number of the data observed and the conclusions to be drawn therefrom have been mentioned in Vol. I, they will, for the convenience of the reader, be to some extent repeated in the following paragraphs, together with certain additional diagnostic signs and symptoms. Lesions of the motor area comprising, as stated in Vol. I, the areas lying in the cortex in the anterior and posterior central gyri separated by the fissure of Rolando, may give rise to fairly definite localizing symptoms. Behind the Rolandic fissure it is believed that the nerves of sense pass to the cortex, and in front of it, as described in Vol. I, the motor nuclei for the muscles of the extremities, trunk, face, etc. Irritation of groups of cells in the motor area may lead to

convulsive movements, which begin in certain muscles or groups of muscles and then spread to other groups presided over by the adjoining motor cortex. The seat of the irritation may often be inferred by studying the onset of the convulsive attacks. The muscles in which the convulsive movements first occur represent that portion of the cortical motor area which is the seat of the lesion. In progressive lesions, such as tumors situated in the motor area, it will often be noted that during the early stages of the disease the symptoms are irritative in character, producing convulsions, and that as the tumor or other lesion increases in size, the nerve cells may be destroyed by pressure or infiltration and the irritative lesion is then followed by a paralysis of the muscles formerly the seat of convulsive movements. Lesions confined to the motor area are not attended by disturbances of sensation.

Lesions in the sensory field or behind the Rolandic fissure in the posterior gyrus, may produce various disturbances of sensation, at first of an irritative character, such as paresthesiæ of various kinds, numbness, tingling, etc. Later in the course of the disease actual loss of sensibility may occur with anesthesia. It is, however, to be borne in mind that cortical lesions may be very extensive without any changes in sensibility, and that from such changes our diagnostic conclusions are only rarely aided to any very marked extent. When, however, a lesion exists in the sensory pathways beneath the cortex, the symptom of anesthesia is apt to be more pronounced.

Degeneration of the pyramidal tract follows a destructive lesion of the anterior gyrus; the deep reflexes are increased and Babinsky's phenomenon is present—i. e., upon mechanical stimulation of the sole of the foot, the great toe is thrown into a condition of strong hyperextension.[1]

Lesions of the Frontal Lobe.—Lesions of the anterior portion of the frontal lobe, if not very extensive, may produce no symptoms whatever, or if symptoms are produced they will be of a general character and will consist of apathy, changes in disposition, or of mental dullness, and evidences of a general weakening of the intelligence. Lesions in the posterior portion of the frontal lobe may produce disturbances in the conjugate movements of the head and of the eyes, together with disturbances of the motor portion of the speech mechanism, speaking and writing. Cushing states that "it is a question of dispute as to which of the frontal lobes presides most definitely over the intellectual faculties, the general consensus of opinion being that in right-handed people the left prefrontal lobe is the more important of the two." The symptoms produced by lesions of the third frontal convolution (Broca's) are disturbances of speech. They have been sufficiently dwelt upon in Vol. I.

The Parietal Lobe.—The parietal lobe is divided into an upper and lower lobule. The lower lobule lies below the interparietal fissure and includes the supramarginal and angular gyri. Although the symptoms produced by lesions of this portion of the brain have been already given in Vol. I, for the conve-

[1] Cushing, *loc. cit.*, p. 164

nience of the reader they are here repeated. They are thus described by Cushing:[1]

One characteristic symptom follows a destructive lesion of the angular gyrus of the left side in right-handed people—namely, *word-blindness* or the inability to appreciate the meaning of written language. A deep-seated lesion which involves the paths radiating from this word-seeing center is apt to involve the optic radiation as well, and consequently to lead to a half-blindness of the corresponding sides of both retinæ.

A lesion of the superior parietal lobule, particularly if it be subcortical, leads to disturbances of *stereognosis;* in other words, of the power to recognize through contact alone, the form or character of objects, or to name unseen objects when they are handled.

In the case of a subcortical lesion, especially if it encroaches on the postcentral gyrus, other sensory disturbances are apt to be present, such as loss of muscle sense, of position in space, or even of forms of common sensation.

The right parietal lobe is a comparatively silent area, given up largely to association paths.

The Occipital Lobe and Visual Pathway.—The former includes the posterior end of the hemisphere, both upon its external and mesial aspects. The parieto-occipital fissure forms its mesial anterior boundary, while it is limited on the convexity by an imaginary line passing from this fissure forward and downward to the annectant convolutions. This lobe includes on its mesial surface the cuneus and lingual gyrus, from which area the optic radiation passes, by the posterior end of the internal capsule, to the thalamus and external geniculate body, and thence by the optic tract to the retinæ. A destructive lesion of this portion of the occipital cortex gives rise to blindness of the homolateral halves of both retinæ (homonymous hemianopsia), the patient being unable, when looking directly forward, to see objects upon the opposite side of the body until they are brought across the median plane. Hemianopsia may not be complete both for form and color, as one or the other may escape, and there are certain cases which indicate that a quadrantal hemianopsia may result from lesions in this situation. Should the lesion be a deep one and involve the optic radiation, homonymous hemianopsia may be accompanied by hemianesthesia or hemiplegia from implication of the adjoining paths for sensation and motion in the internal capsule.

The symptom hemianopsia is such a very important one in diagnosis, and leads to such definite conclusions, that the author feels that no apology is necessary for giving another short quotation from Cushing in regard to this group of symptoms.[2]

When hemianopsia occurs suddenly with symptoms of vascular obstruction it usually indicates occlusion of the cerebral artery in the neighboring calcarine fissure. In these cases of hemianopsia from cortical lesions, the pupils react in the usual manner when a ray of light is thrown on the blind halves of the retinæ (Wernicke's hemiopic pupillary reaction). A lesion of the optic tract must be anterior to the oculo-motor nuclei to abolish this reflex. . . .

[1] Cushing, *loc. cit.*, p. 165. [2] *Ibid.*, p. 166.

Irritative lesions of the occipital lobe may give rise to subjective flashes of light or of colors and these phenomena may constitute an aura for general epileptic convulsions originating from an organic process here. Experimentalists have been led to believe that centers for certain movements of the eyes are situated in the occipital lobe. If actually present they are of no diagnostic significance.

The Temporal Lobe.—A large portion of the temporal lobe, lying as it does beneath the fissure of Sylvius, and forming a considerable part of the under surface of the hemisphere, is a silent region of the brain, since large destructive lesions may here exist without producing symptoms. As stated in Vol. I, the superior temporal convolution on the left side presides over the power to appreciate spoken language, and destructive lesions of this part produce so-called "word-deafness."

The uncinate gyrus situated at the lower and anterior part of the temporal lobe is associated with the senses of taste and of smell. Irritative lesions in this region which lead to epileptic attacks may have as an aura the subjective sensation of some peculiar taste or odor. The function of a large portion of the temporo-sphenoidal lobe is unknown.

The disturbances produced by lesions of the basal ganglia, the crura cerebri, the pons, and the corpora quadrigemina, as well as the symptoms produced by lesions of the cerebellum, have been sufficiently dwelt upon in Vol. I.

TUMORS OF THE BRAIN AND THEIR DIAGNOSIS

Every variety of tumor, with few exceptions, has been observed in the brain as a primary or secondary growth. The most frequent types are the endotheliomata. As they occur in the brain they are fairly benign forms of tumor; they usually originate in the meninges and have a distinct capsule, so that if accessible to operation they are quite readily removed.

Glioma and combinations of glioma with sarcoma arise from the connective-tissue framework of the neuroglia. They are soft infiltrating tumors and are prone to undergo cystic and other forms of degeneration. They are among the less favorable types of cerebral growth for operation.

Cystic tumors, usually of parasitic origin (echinococcus), or, in other cases as the result of trauma, are not very rare in the brain. The history of their growth is that as the tumor increases in size it leads to pressure symptoms. Carcinoma occurs in the brain as a metastatic tumor, and is, therefore, rarely suitable for operation. The metastases occur most often in the bones of the skull than elsewhere and secondarily invade the cranial cavity. The sarcomata may occur primarily in the brain or as metastatic tumors. In the latter group of cases they most commonly originate in the skull. Nearly all the various forms of benign new growths of the connective-tissue type are occasionally observed in the interior of the skull.

In addition to true tumor formation, syphilitic gummata and localized areas of tuberculous infiltration are not very rare in the interior of the skull. They

produce symptoms which are scarcely to be differentiated from true tumor formation. The following favorite sites for the occurrence of the several forms of tumor most commonly observed in the brain are those given by Cushing: [1]

Tuberculous infiltrations are more common in the cerebellum than elsewhere, syphilitic gummata originate most often in the meninges at the base of the brain. Endothelioma in the meninges of the subtentorial region, cysts in the cortex, cholesteatoma in the temporal lobe, teratoma in the pituitary body and mid-basal region.

The **symptoms** produced by tumors of the brain may be divided into two groups—namely, symptoms due to a *generalized increase of intracranial pressure* and symptoms of a *local* character due to the *destruction* or *irritation* of the part of the brain involved in the tumor. The most constant general symptoms of tumors of the brain are *headache, vomiting,* and *choked disk.* It is, however, to be borne in mind that if a tumor is situated in one of the areas of the brain whose destruction does not produce definite symptoms, or if the tumor merely infiltrates the brain without increase of intracranial pressure, it may reach a large size without producing any symptoms whatsoever. In some of these cases the death of the individual is preceded merely for hours or days by the symptoms of a cerebral apoplexy from hemorrhage into the growth, or the patient may suddenly develop general convulsions, delirium, and coma, followed by death within a few days.

The HEADACHE produced by tumors of the brain may be a generalized dull headache, which is more or less constant, but is usually more severe in the morning, or it may be a headache referred to some particular region—the occiput, the forehead, the temporal region, etc. It is rare that the headache is of diagnostic value in locating the seat of a tumor, unless, as occasionally happens, the pain is always referred to the same spot and is accompanied by tenderness on percussion over the skull at this point. The headache in some cases of tumors of the brain may become progressively worse, and finally reach an agonizing character.

VOMITING.—The vomiting which occurs in tumors of the brain may be frequent, or occur at irregular intervals, or the symptom may be entirely absent. The vomiting is frequently of a projectile character, and it may come on suddenly, independently of the ingestion of food. It may or may not be accompanied by nausea. It is sometimes made worse when the patient stands erect or sits up after lying in bed, and is most frequently observed upon rising in the morning.

CHOKED DISK.—Choked disk is one of the most constant signs of tumor of the brain. It must be, however, differentiated from similar appearances in the fundus of the eye complicating nephritis. If a tumor is situated to one side of the median line in the front part of the brain, it may give rise to

[1] Cushing, *loc. cit.*, p. 221.

choked disk confined to one eye. When the tumor is situated at some distance from the orbit, the choked disk is observed as a bilateral lesion. It is to be borne in mind that in any case of tumor of the brain any one of these symptoms may be slight or absent, or may not be developed until late in the disease.

Local Symptoms.—Local symptoms may or may not be present in tumor of the brain, even though the tumor be of considerable size. This fact is explicable upon the ground that there are large portions of the brain whose function is unknown and whose injury or destruction give rise to no symptoms which we are able to recognize. In some instances general symptoms will be present, as well as localizing ones; in others, there may be distinct localizing symptoms without headache, vomiting, or choked disk.

Tumors which invade the motor area will usually be attended by symptoms of irritation followed by those of paralysis. The location of the tumor may sometimes be quite accurately made out by observing the particular groups of muscles which undergo convulsive contractions, as the result of irritation, and the same is true of the paralytic symptoms. Tumors which invade the area of the brain just behind the motor area may give rise to sensory disturbances, such as have been described in a preceding paragraph. Their diagnostic value is, however, less than that of the motor symptoms. Tumors of the frontal lobe frequently give rise to no localizing symptoms whatever, and, as has elsewhere been stated, the only symptoms produced for a long time may be changes in the disposition, restlessness, mental apathy, stupor, etc. Tumors of one lateral occipital lobe produce hemianopsia. If both lobes are involved, blindness is produced. In regard to tumors in the parietal lobe, Cushing states as follows: [1]

> Tumors in the parietal lobe may also lead to Jacksonian attacks preceded by sensory symptoms. A degree of aphasia is apt to be present when the left angular gyrus is involved, with especial loss of understanding of written words and letters (word-blindness). On the advance of these tumors there may be some permanent disturbance with sensation of the cortical type (involvement of extremities more than trunk) on the contralateral side of the body; also disturbances with muscle sense, posture sense, or sense of position in space; also inability to recognize the form or consistence and to name objects placed in the affected hand—astereognosis.

Tumors of the temporal lobe may produce no notable symptoms until they have extended to the lower motor centers of the cortex. If they involve the superior temporal gyrus upon the left side, they may produce word-deafness. At the apex of the temporal lobe in the uncinate gyrus lie the centers for taste and smell, and these senses may be interfered with by tumors in this situation, or attacks of epilepsy may occur with an olfactory or gustatory aura. Tumors of the corpus callosum and of the mesial surface of the cerebellum usually produce no localizing symptoms, but may be attended by progressive loss of mental activity, these symptoms resembling those produced by tumors of the frontal lobe.

[1] Cushing, *loc. cit.*, p. 225.

Tumors of the basal ganglia may cause a variety of symptoms. These tumors, of course, are not accessible to surgical treatment. According to Cushing,[1] the following groups of symptoms may occur: Pressure upon the internal capsule causes interference with the motor and sensory pathways to the cortex, thus hemiplegia, hemianesthesia, hemiataxia, or hemianopsia may occur:

Lesions of the thalamus are apt to cause athetoid movements or tremors of the opposite limbs. The deep reflexes may be increased; the superficial absent—Babinski's toe phenomenon in particular. Muscular sense and stereognosis are usually affected.

Tumors of the corpora quadrigemina lead to a staggering gait, a tendency to fall to one side and backward, to a failure of sight and hearing, to nystagmus and to palsies of the ocular movements without true paralysis of the oculomotor nerves.

Tumors of the pons and of the crura cerebri are not amenable to surgical treatment. The general symptoms are apt to overshadow the localizing ones.

Tumors of the cerebellum give rise quite early to choked disk, together with signs of increased intracranial pressure. In tumors situated within the cerebellum, giddiness and vertigo are common symptoms. The localizing symptoms are a staggering gait, a tendency to fall to one side, sometimes toward the side of the lesion; there is muscular weakness and ataxia most marked upon the side of the tumor. The head is sometimes held tilted toward the side of the lesion, while the face is rotated toward the opposite side. Nystagmus is a common symptom. There may be localized tenderness of the skull beneath the occiput. In regard to tumors situated close to but outside the cerebellum, Cushing [2] states as follows:

Extracerebellar tumors favorable for operative removal often lie in the cerebello-pontine recess and cerebral nerve symptoms are always present. These growths are supposed to arise from the acoustic nerve, and tinnitus with unilateral deafness is often the first symptom. They enlarge slowly and it may be years before some pressure palsy of the facial, abducens, or trigeminal nerve occurs. The growth in time compresses the lateral lobe of the cerebellum and pons, when local symptoms similar to those recounted above will put in an appearance. General symptoms also may ultimately appear from closure of the iter, though they may be delayed for years.

Tumors of the pituitary body may produce hemianopsia. In a certain number of cases acromegaly may develop with the symptoms common to this disease. Headache, convulsions, vomiting, apathy, mental deterioration are not uncommon.

In regard to the diagnosis of tumors of the brain in general, it may be said that when favorably situated their situation may be more or less accurately inferred, and that in a certain proportion of cases their successful operative removal is possible. As elsewhere indicated, however, a tumor of con-

[1] Cushing, *loc. cit.*, p. 226.

[2] *Ibid.*, p. 228.

siderable size may exist in several areas of the brain, notably in the frontal and temporal regions, without producing any localizing symptoms, and until the tumor has attained a very large size but few generalized symptoms. It has been shown that in a *few cases* the situation of a tumor in the brain may be demonstrated by means of the X-rays. If the tumor has produced bony destruction or a new growth of bone, these lesions may show in the X-ray plate and thus aid in the diagnosis. In the diagnosis of brain tumors it is necessary to exclude syphilis, tuberculosis, abscess of the brain, and meningitis from other causes, as well as chronic nephritis. Some of these conditions can be diagnosticated with probability by means of a lumbar puncture, but Cushing calls attention to the fact that if a tumor is present lumbar puncture is a *dangerous procedure,* and may be followed by sudden death.

ADDITIONAL REMARKS IN REGARD TO GUNSHOT WOUNDS PRODUCED BY MILITARY RIFLE BULLETS OF THE MOST RECENT TYPE

At the present time, Germany, England, and France have adopted a military rifle which fires a bullet of a caliber of 88 mm. The bullet differs from those used by other nations in certain particulars. Instead of a rounded or ogival point, the bullet is sharply pointed. It is probable that other nations will soon adopt this form of bullet. The pointed bullet offers less resistance to the air than other forms, and consequently a flatter trajectory is possible. The center of gravity of the bullet lies nearer its base than in the ogival-tipped bullets, and this produces, so it is said, a tendency for the bullet to tip over after it has reached a certain point in its flight. In order to overcome this tendency at ordinary ranges, the initial velocity given to the bullet is very high indeed. The German bullet is 27.8 mm. long and weighs 10.0 gms. A review of the experiments of others and the results of certain experiments made by himself have been published by Dr. F. Riedinger, and from his monograph the following data are derived: [1]

The powder load is 3.2 gms. On account of the relatively small weight of the cartridges, soldiers are able to carry a larger number without notable effort. The rifle is most efficient up to ranges of from 800 to 1,000 meters. The initial velocity of the bullet is 855 meters per second. The extreme range is 4,500 meters. At a range of 800 meters the bullet will perforate in a sagittal direction any portion of the human body. At the same range, if the body is struck lengthwise, wounds are observed from 400 to 600 mm. in length. If at this range the bullet strikes flatwise, a wound of 130 mm. deep may be produced. At very great ranges the weapon is less efficient than the military rifles at present in use by other nations, and at similar ranges the bullet shows a decided tendency to tip over. It is, therefore, probable that wounds made by the bullet striking flatwise will be more common. Further, there is some tendency for the bullet to be deflected when it strikes hard bone.

[1] "Über die Wirkung moderner Projektile," by Dr. F. Riedinger.

In general, the destruction of bones and soft parts and the wounds produced closely resemble those made by the ordinary ogival-pointed bullet. In the shafts of the long bones the bullet produces comminuted fractures, the area of comminution and the lines of fracture suggest in shape the outlines of an ordinary envelope, or in other cases the outspread wings of a butterfly. At close ranges a large number of minute bone fragments are produced of a generally quadrilateral shape. At increased ranges the comminution is less marked, the number of fragments is smaller, and the size of the individual fragments greater. In these particulars the wounds do not differ markedly from those ordinarily observed. Comminution of the shafts of long bones, tibia and femur, is observed up to a range of 2,000 meters. If the shaft of the long bone is struck near its border without opening the medullary canal, a groove may be cut in the bone without notable comminution and without any marked radiating lines of fracture. (Fessler.)

Upon the spongy ends of the long bones simple perforations are often produced, resembling those made by the ogival-pointed bullet. In other cases perforation occurs with more or less marked radiating lines of fracture. The more nearly the wound approaches the hollow diaphysis of the bone, the more marked is the splintering and comminution.

The wound of entrance in the skin from direct shots is very small, smaller usually than the diameter of the bullet. The edges of the wound usually show fine radiating tears. The wound of entrance is slightly stained of a grayish color, due to powder residue which clings to the bullet. It is thus possible to differentiate the wound of entrance from the wound of exit. If the bullet strikes the skin obliquely or flatwise, the wound of entrance will, of course, be larger and of a different shape. The wound of exit is also, as a rule, quite small, irrespective of the amount of destruction of the bone or subcutaneous soft parts. When bones are fractured, minute particles of bone are scattered through the tissues and may sometimes be seen in the wound of exit. If the bullets strike flatwise the wound of exit is usually much larger, and through it torn tendons and muscular bellies may protrude.

Riedinger says in regard to the most modern French military rifle that the ball is solid; it consists of copper, to which a small amount of zinc is added. It is pointed at the end, resembling in shape a torpedo or cigar. It is longer than the German bullet, 39.9 mm. as compared with 27.8 mm. The caliber is 8.0 mm. The bullet weighs 13.2 gms., and is therefore heavier than the German bullet. The initial velocity, however, is lower, 730 as compared with 830 meters. The trajectory is not as flat as the German rifle, but the weapon is effective at greater ranges.

Riedinger considers that the most important differences in the wounds produced by these pointed bullets will depend upon the tendency for the bullet to be upset in its flight and to strike flatwise. Sufficient observations have not as yet been made to determine how often such wounds will occur. If the bullet strikes point foremost, wounds of the soft parts alone will probably be

simpler even than those produced by the ogival bullet, and the same will be true for wounds of the spongy bones. If, on the other hand, the bullet upsets, a considerable cavity will be produced in the track of the wound. The wounds of the shafts of the long bones do not differ materially from those made by other small-caliber bullets. When the bullets strike flatwise the destruction of both bone and soft parts will be greater. The wounds of entrance and exit will be larger and aseptic healing will be more difficult to obtain. Riedinger says, that, if the bullet strikes some very massive obstruction when moving at high velocity, any massive hard portion of bone, for example, the mantle may be torn and the leaden core of the bullet may split up into fragments, producing very severe wounds.

Whether this will happen more frequently than formerly cannot at present be said. The pointed bullet is even more apt to make a clean perforation in blood-vessels than the ogival form. Wounds of nerve trunks will probably resemble those already observed. Fessler fired twelve experimental shots through the abdomen. In all but one the intestine was wounded. The effects upon the skull were said to be even more destructive than usual. Wounds of the thorax, when the bullet preserves its proper line of flight, will not differ from those produced by the ogival bullet. If, however, the bullet is upset and strikes flatwise, more serious injuries are to be expected. Thus a certain proportion of the wounds will be more serious than ordinary, and there will exist another group in which the injuries will be relatively slight.

With the exception of the greater tendency of these bullets to upset in their flight, or to upset when they strike bone, it does not seem to me that the wounds produced are likely to differ materially from those ordinarily observed.

In regard to the cavalry arm of the U. S. military service, recent experience and experiments seem to show that revolvers of .38 caliber are not sufficiently powerful and do not produce sufficient shock to stop a charging horse, unless the shot be a particularly fortunate one. Experiments were conducted upon steers for the purpose of testing the stopping power of various pistols. It was found that a heavy revolver of .45 caliber, when fired through the body of an ox, would nearly always cause it to drop instantly so that it was unable to regain its feet. Revolvers with lighter bullets and of smaller calibers fail to do this. The revolvers, therefore, of the United States cavalry have been, or will be, increased in size and caliber.

THE SERUM DIAGNOSIS OF SYPHILIS

In order to understand the serum diagnosis of syphilis known as the Wassermann-Neisser-Bruck reaction, it is necessary to be informed in regard to the phenomena and principles of *hemolysis* and to know what is meant by the Bordet-Gengou phenomenon. The matter is a little complicated, and for those unfamiliar with the methods of a modern bacteriological and biological laboratory, the technic is somewhat confusing. In the following paragraphs I

shall attempt to make the matter clear by defining the various terms used in describing these reactions, and shall add the simplified technic of Noguchi, who has developed a method for making the test for syphilis so simple that it can be carried out by any doctor who is familiar with blood-counting, urinary analysis, etc. In a paper by Dr. Howard Fox, of New York, read January 18, 1909, before the Medical Association of the Greater City of New York, the principles of hemolysis and of the Wassermann reaction are very clearly told, and I am largely indebted to that paper for the following data.

The technic of the Noguchi modification of the reaction is taken from an article in the *Journal of Experimental Medicine* by Noguchi.

If the blood *serum* of an animal of a certain species be added to the blood *corpuscles* taken from an animal of another species, the serum will cause a solution of the corpuscles. This process or phenomenon is known as hemolysis. If, for example, to sheep's corpuscles there is added blood serum of a rabbit, the corpuscles of the sheep will be in part dissolved. If now the rabbit receives several injections of sheep's corpuscles, it will be found, after a time, that the serum of this rabbit possesses a greatly increased power to dissolve sheep's corpuscles. By the injection a substance has been formed in the serum of the rabbit which is known as *hemolytic amboceptor*, or immune body, and the rabbit is said to be immunized against sheep's corpuscles. Heating of the serum for half an hour to 56° C. does not destroy the power of this substance to dissolve corpuscles, and the substance produced is said to be *thermostabile*. The solution of the corpuscles depends, however, not alone upon the hemolytic amboceptor thus formed, but upon another substance present in the serum of all normal animals, which is known as *complement*. This substance is destroyed by heating to 56° C. for half an hour, and is said to be thermolabile. "The three substances—corpuscles, hemolytic aboceptor, and complement—constitute what is called a hemolytic system. Hemolysis can take place only when all three are present." The word amboceptor indicates that the substance has an affinity for corpuscles and also for complement. The substance called complement receives this name because it serves to complete the action of the amboceptor. The following quotation from the article of Dr. Fox serves to render clear the principles of these hemolytic reactions.

Closely analogous to a hemolytic system is what may be termed a "bacteriolytic system," consisting of (1) a bacterium, corresponding to the corpuscles in the hemolytic system, (2) a bacteriolytic amboceptor (or antibody) corresponding to the hemolytic amboceptor, and (3) complement, similar in both systems. Before proceeding to discuss this so-called bacteriolytic system, it is necessary to explain the terms antigen and antibody. An antigen is any substance (bacteria, corpuscles, body cells, etc.) which, when introduced into an animal, is followed by the formation of antibodies. The sheep's corpuscles in the case of the hemolytic system and the bacteria in that of the bacteriolytic system are examples of antigen. The substances formed by their entrance into the animal are antibodies or amboceptors. Strychnin, for instance, though an injurious substance, is not an antigen, as its

entrance into the body is not followed by the formation of antibodies. Furthermore, it should be said that the term antibody does not necessarily imply a substance that is protective, such as an antitoxin.

Returning to the bacteriolytic system, and taking a specific instance, we will use for antigen an emulsion of the typhoid bacillus; for bacteriolytic amboceptor or (antibody) the serum of a patient suffering from typhoid fever; and for complement, normal fresh serum, preferably from a guinea-pig. If these three substances—typhoid bacilli, typhoid amboceptor, complement—are placed in a tube for half an hour at body temperature, a union will take place just as it did in the case of the hemolytic system. The bacteria, instead of the corpuscles, are dissolved. Unlike what occurs in the hemolytic system, the union of these three substances will not be followed by any visible change. It cannot be told from the appearance of the tubes whether or not the bacteria have been dissolved. In the case of the corpuscles, solution was most apparent, the tubes changing from an opaque to a clear red color upon hemolysis. In other words, in the hemolytic system there was an indicator to show that solution of the corpuscles had taken place, no such indicator being present in the case of the bacteriolytic system.

Bacteriolytic System Consists of	Hemolytic System Consists of
1. Bacterium (antigen).	1. Corpuscles (antigen).
2. Bacteriolytic amboceptor (antibody).	2. Hemolytic amboceptor (antibody).
3. Complement.	3. Complement.

The reaction discovered by Bordet and Gengou in 1901 utilizes the phenomenon of hemolysis to show that a union actually can occur between the three components of a bacteriolytic system. This reaction depends upon the so-called principle of the fixation (anchoring or binding) of the complement, and is carried out as follows: The three components of a bacteriolytic system, such as typhoid bacilli, typhoid antibodies (serum of patient to be tested), complement, are placed in a test-tube and incubated at 37° C. for a half hour to allow them to unite. To the same tube are then added two of the elements of a hemolytic system—namely, hemolytic amboceptor and sheep's corpuscles, and the mixture again placed in the incubator. If now there has been an actual union of the first three substances—that is, if the complement has been fixed or used up by uniting with the other two substances, there will be no complement left to unite with the other two parts of the hemolytic system, and consequently no hemolysis will occur. If, on the other hand, no union of the first three substances had occurred, complement will be available to unite with the other two parts of the hemolytic system, and consequently hemolysis will take place. In other words, the absence of hemolysis denotes a positive reaction—i. e., the antibodies for which we were testing are present. In the case in question, the patient was suffering from typhoid fever. The occurrence of hemolysis, on the other hand, signifies a negative reaction—i. e., the antibodies were not present. In that case the patient was not suffering from typhoid fever.

The reason for using guinea-pig serum for complement is that the complement present in the serum of the individual to be tested is variable and of

unknown quantity. For this reason the complement in the patient's serum is destroyed by heating to 56° C. for half an hour, and the complement is furnished by using a measured quantity of guinea-pig serum. In testing for syphilis, the principle of Bordet and Gengou has been used in the same way as in testing for the presence of typhoid antibodies, but inasmuch as the spirocheta of syphilis has not as yet been cultivated, it has been necessary to use the liver of a syphilitic fetus in which the presence of the spirocheta could be demonstrated. It has been found, however, by experiment, that numerous other substances may be substituted for syphilitic liver, and Noguchi has found that a solution of lecithin may be used as antigen instead of an extract of syphilitic organs. Other modifications have been made by him, presently to be described, which render the technic of the test much more simple.

Inasmuch as Noguchi's modification of the Wassermann reaction is much simpler in technic than any hitherto employed, and will probably become the standard method for making the serum test of syphilis, I have omitted a description of the earlier methods of making the test, since not only are they very complicated, but also because they are only suited for a fully equipped laboratory. Moreover, the older tests require a degree of technical skill on the part of the observer only possessed by those thoroughly acquainted with the technic of sero-diagnosis. Noguchi's method is described by him in the *Journal of Experimental Medicine*, Vol. XI, No. 2, 1909. I have thought it better to quote directly from his description rather than to attempt to put his technic into my own words. Noguchi considers that his method is more accurate and more reliable than the Wassermann test, and he sums up his results as follows:

Four hundred and sixty-five specimens of serum were examined by his method and 115 of these were also examined by the original Wassermann test. The results were as follows: Of 7 cases of primary syphilis, the Wassermann test was positive in 5; the Noguchi test in all. In 27 cases of manifest secondary syphilis, the Wassermann test was positive in 23; the Noguchi test in 27. In 12 cases of latent secondary syphilis, the Wassermann test was positive in 6; the Noguchi test in 9. In 18 cases of manifest tertiary syphilis, the two methods agreed and were positive in 17. In 18 cases of latent tertiary syphilis, the Wassermann test was positive in 11; the Noguchi test in 14. In 11 untabulated cases of tabes dorsalis, 3 were positive with the Wassermann test and all were positive with the Noguchi test. In 28 cases suspected of syphilis or of syphilitic origin, the Wassermann test was positive in 16; the Noguchi test in 21.

Noguchi considers that not only is the method very valuable in diagnosis, but also forms a valuable guide for the treatment of cases of syphilis. He says that under treatment not only do the symptoms of the disease abate, but the blood reaction grows weaker until ultimately, when the cure is complete, the reaction can no longer be obtained. If further experience should support this

view, the duration of treatment in cases of syphilis and its efficiency might be accurately measured.

The new method is based upon the same principle as Wassermann's and utilizes the Bordet-Gengou phenomenon of complement-fixation to determine the presence of the syphilitic antibody in a given specimen of blood serum or cerebro-spinal fluid. It differs, however, from the Wassermann method in using an antihuman hemolytic system instead of an antisheep hemolytic system. This difference may at first seem of trifling importance, but it really is very significant since it affects the accuracy, ease, and reliability with which the test can be applied. Wassermann's original method, it may be added for the sake of clarity, is subject to an error arising from the presence in human serum of a varying amount of natural amboceptor capable of being reactivated by guinea-pig's complement. Many specimens of human serum contain in 0.1 c.c., which is the quantity usually employed in a test for complement fixation, as many as twenty units of antisheep amboceptor, while some specimens are entirely devoid of this amboceptor. I found by actual experiment that four units, but not two units, of the natural antisheep amboceptor prevent entirely the detection of one unit of syphilis antibody. When eight units of natural antisheep amboceptor and two units of syphilis antibody are bought together, the test remains completely negative. In other words, by the method of Wassermann the presence of syphilis antibody may be missed, although in the absence of the natural antisheep amboceptor it would be readily detectible. This defect in the complement fixation system is not only inherent to the Wassermann method but also to all those which employ foreign blood corpuscles for which human serum contains natural hemolytic amboceptors capable of being reactivated by the complement employed in the test.

I believe that the method which I have worked out eliminates completely this source of error, because human blood corpuscles are used as the hemolytic indicator in combination with human serum, so that as no foreign natural hemolytic amboceptor is accidentally present, its effects are excluded. The present method of the complement fixation test is carried out under conditions of definite and uniform sensitization of the blood corpuscles, thus enabling one to detect the presence of even a fractional part of one unit of syphilis antibody in a given specimen. It is impossible to miss one or more units of the antibody, which happens not infrequently with the Wassermann and similar methods.

Description of the Method

In order to carry out the present method of diagnosis it is needless to say that the serum of the patient under question must be obtained. The patient's serum is then subjected to the usual complement fixation test with the reagent to be described immediately below and according to the technic specially adapted for the present method. I have developed so far two different ways of applying the test. In one the reagents are employed in liquid form and in the other, the reagents are used in a dried state on filter paper. The first way of making the test is adapted to general biological laboratories, and the second is adapted especially for the clinical laboratory. The descriptions which follow immediately refer to the laboratory method, but they do not differ essentially from those for the clin-

laboratory except that the reagents employed are in the two different forms mentioned.

Reagents Required for the Method

The following reagents are required for making a test by the present method:

1. *Antihuman hemolytic amboceptor* prepared in rabbits by injecting them five or six times into the peritoneal cavity with increasing doses (up to 20 c.c.) of washed human blood corpuscles, allowing five days' interval between each inpection. The serum is collected from the immunized animal eight or nine days after the last injection. The titre must be stronger than 0.001 c.c. for complete hemolysis. I now use a serum of 0.001 c.c. titre.

2. *Complement.*—Fresh guinea-pig serum.

3. *Antigen.*—Alcoholic extract of organs or preparations of crude lecithin. To prepare the alcoholic extract of organs one part of mashed tissue (liver, kidney) is extracted with ten parts of absolute alcohol for several days at 37° C., filtered through paper and the filtrate concentrated to about one third of its volume, and the fluid preserved. To prepare the lecithin solution for antigen, 0.3 gram is dissolved in 50 c.c. of absolute alcohol and then shaken with 50 c.c. of physiological salt solution and filtered. The filtrate must be clear.

4. *Suspension of Human Blood Corpuscles.*—This is prepared by mixing one drop of the blood of a normal person with 4 c.c. of physiological salt solution. It is preferable to remove all the serum constituents by washing the corpuscles. This is easily accomplished by allowing the suspension to stand overnight, then decanting the supernatant fluid and resuspending the sedimented corpuscles in a fresh lot of saline solution.

5. *The Serum to be Tested.*—About ten drops of blood from a patient are collected in a small test tube. The clear serum separated from the clot is employed for the test.

Method of Making the Test

1. Take six clean test tubes (size 10 cm. x 1 cm.). In the first two of these, place one drop from a capillary pipette (or two if necessary) of the patient's serum which is to be tested. In each of the second two tubes (which are to serve as controls) put one drop of the serum of a syphilitic case known to give the positive reaction. In each of the third pair of tubes (also controls) put one drop of the serum of a normal person. In case of using inactivated sera (56° C.) 4 or 5 drops are required. Now to each of the six tubes add 1 c.c. of the suspension of human blood corpuscles and 0.04 cc. of fresh guinea-pig serum as complement. Lastly, into one of each of the three foregoing pairs of tubes put one drop of the antigen solution from a capillary pipette. The second tube of each pair receives no antigen.

2. After being well mixed by shaking, the six tubes are incubated at 37° C. for one hour.

3. At the end of the incubation, add two units of antihuman amboceptor to each tube and mix well by shaking. Incubate the tubes for two hours longer at 37° C. Read the reaction from time to time for the next ten to twelve hours, during which the tubes are kept at room temperature.

The complete test is shown in the following chart:

CHART I

	Test for Diagnosis.	First Control Set.[1] Test with a Known Syphilitic Serum (Positive Reaction).	Second Control Set.[2] Test with a Normal Serum (Negative Reaction).
Control tube without antigen for each test.	a. Patient's serum. b. Human blood suspension. c. Complement.	a′. Positive luetic suspension. b. Human blood suspension. c. Complement.	a″. Normal serum. b. Human blood. c. Complement.
Determinative tube containing antigen.	a. b. c. } ditto. d. Antigen.	a′. b. c. } ditto. d. Antigen.	a″. b. c. } ditto. d. Antigen.
	Incubation at 37° C. for one hour. Antihuman hemolytic amboceptor to all tubes. Incubation at 37° C. for two hours longer, then at room temperature.		

It is necessary to begin the test with one drop of the patient's serum. If the reaction is negative the test should be repeated with two drops. Sera are not infrequently met with, however, in which two drops are inhibitory without the presence of antigen. On this account it is undesirable to use two drops as routine. Usually one drop reveals the presence of the specific antibody if it is present at all, and further test becomes almost unnecessary.

Reading of the Reaction

A negative reaction is indicated by complete hemolysis in both tubes irrespective of the presence of the antigen. On the other hand, a positive reaction is shown by complete absence or partial inhibition of hemolysis in the tube containing the antigen and complete hemolysis in the tube without the antigen.

Complete hemolysis in the negative control takes place usually within one hour or sometimes earlier. When the reaction is strongly positive, as it should be with the positive control set, the tube with the antigen remains absolutely free from any trace of hemolysis even after a few days' standing at room temperature. In such a case the erythrocytes are strongly agglutinated and remain adherent to the bottom of the test-tube, leaving above a perfectly clear medium. In moderately positive cases there is a trace of hemolysis, while the varying degree of positive reaction can readily be measured by the amount of the hemoglobin liberated in the medium and especially by the amount of intact red corpuscles remaining in the fibrin shreds or whitish stroma masses. It should be mentioned that the tubes containing the antigen undergo hemolysis somewhat more slowly than those without antigen, but complete hemolysis must occur in both tubes of the negative control set, before the reaction of the other sets of tests is read. It is also necessary to note that every tube without antigen, irrespective of the nature of the specimen of

[1] When many specimens of syphilitic sera are subjected to simultaneous tests this set of controls is scarcely necessary, as we usually find a good positive serum among them.

[2] This control set may be made without the addition of any human serum.

blood serum therein contained, must undergo complete, or at least almost, complete hemolysis before the final reading of reaction is made. In cases in which tubes without antigen do not undergo hemolysis the test must be repeated with a smaller quantity of the human serum in order to obtain a definite result.

Simplified Method for the Clinical Laboratory

The method so far described is much simpler than the original test of Wassermann and can be quickly and easily carried out in any laboratory where experimental work with serum is constantly being conducted. I have, moreover, been able so to modify the methods of handling the various factors in the test that it should be possible to carry it out with accuracy and dispatch in any clinical laboratory. These further modifications consist essentially in drying the reagents on paper and standardizing them. In this form they can be prepared on a large scale by commercial biological laboratories under supervision of a competent serologist, and placed on the market within ready reach of physicians. My experiments have shown that it is possible to do this with great accuracy and that the preparations so made are stable when kept under ordinary conditions. In the following paragraphs I will describe the method of preparing the filter paper reagents and the mode of employing them for the test.

Antihuman Amboceptor Slips.—The serum of immune rabbits is taken up with filter paper and quickly dried (a few hours) by a current of air at low temperature (below 20° C.). If the immune serum is not very strong—the titre 0.01 c.c. for example—the serum should first be concentrated to one third of its volume by means of a current of air before the paper is impregnated. (This is necessary in order to secure a slip of small dimensions for convenient use.) After complete desiccation, the impregnated paper is cut into pieces of equal dimensions, each one being of such a size as to contain two units of the amboceptor.

Complement Slips.—A rather thick filter paper is impregnated with fresh guinea-pig serum, similarly dried and cut into pieces of equal size. The activity of the complement slip must be titrated and compared with the fresh complement. The activity of the slip complement may vary somewhat with every preparation, but one slip should possess such an activity as to correspond with that of 0.04 c.c. of the fresh guinea-pig serum.

Antigen Slips.—A crude preparation of lecithin of previously known antigenic value is dissolved in ether and similarly taken up into filter paper. It is also easy to impregnate the paper with the alcoholic organ extracts (such as from the liver of a congenitally syphilitic fetus), but a preliminary concentration of the extract by means of a current of air is necessary in this case. After impregnation and complete desiccation, the impregnated paper is cut into equal parts, each being of such a size as to contain enough antigen for one tube.

These three reagents, the antihuman hemolytic amboceptor, guinea-pig complement and antigen, in the impregnated filter papers, can be kept indefinitely at room temperature in a dry place. I have adopted as the dimensions of each slip the size of about 5 mm. by 5 mm. It is understood that preliminary tests should always be made with the slips to prove activity and strength.

In employing the filter-paper slips, they are dropped by means of forceps into the test-tubes already containing the human blood suspension and patient's serum,

in the order and at the intervals already stated for the respective reagents (complement, antigen, amboceptor) in the description for the method of making the test (Chart I). It is necessary to shake the tubes a few times at intervals in order to insure proper solution of the reagents. The incubation may be carried out perfectly well in the vest pocket if a thermostat is not at hand. Confusion is to be avoided by carefully labeling the various tubes. Each of the pairs of tubes making up, respectively, the test, and the two control sets, may conveniently be held together by a rubber band. There can be no confusion within one pair of tests since one of the two tubes contains one more slip (antigen) than the other.

I should advise anyone contemplating the use of the method to make a few preliminary trials, comparing cases definitely syphilitic with normal individuals before undertaking the diagnosis of cases of unknown nature. This would also have the advantage of accustoming the physician to the order of the procedures and the reactions and serves as a test of the reliability of the reagents.[1]

SOME REMARKS ON RECENT STUDY OF STATUS LYMPHATICUS

The condition of *status lymphaticus* has interested surgeons and medical men to a considerable extent during recent years. The subjects of this peculiar congenital disability are, as is well known, individuals of very greatly diminished resistance against both injury and disease. Many of them die during infancy and childhood, a moderate number arrive at adult life, but all of them are more susceptible to infectious diseases, to which they frequently succumb. They die readily from comparatively trifling traumatisms, are exceedingly bad subjects for surgical operations, and not infrequently die as the result of the administration of ether or chloroform. Hitherto, however, though the condition has been well recognized and numerous studies have been made of the bodies of these patients after death, the diagnostic signs and symptoms present during life have not been, up to a very recent period, sufficiently well known and understood to permit us to recognize these cases readily.

The condition is a congenital one and occurs with much greater frequency than was formerly supposed. Recently Dr. Charles Norris has made extensive investigations into the postmortem appearances of these cases in the pathological laboratory of Bellevue Hospital. He has not as yet finished his studies, nor has he been able up to the present time to satisfy himself completely in regard to the pathology of the condition, so that his conclusions are as yet given tentatively. In a preliminary report, however, read at the meeting of the Society of American Pathologists and Bacteriologists in Boston, May 9, 1909, he has formulated certain diagnostic data whereby he believes that the *status lymphaticus* may be quite readily recognized during life. Dr. Norris has kindly placed in my hands this preliminary paper, which is entitled "A Postmortem Study of Status Lymphaticus in Adults and Children with Remarks

[1] For the most recent reports on the value of the sero-reactions for syphilis, the reader is referred to three papers in *The Journal of the American Medical Association*, Vol. LIII, No. 12, September 18, 1909, by Sachs, Noguchi and Castelli, together with the discussion.

upon its Clinical Significance and Diagnosis." The following data are taken from this report. Dr. Norris says that his observations of the *status lymphaticus* have taught him how to recognize the characteristic external appearances in the cadavers of such cases, and he believes that the possibility of making a diagnosis of such cases during life has been established. He says that he finds very characteristic external appearances in the bodies of these individuals and states as follows:

External Appearances

The body is graceful in its proportions, except in disease, well-nourished, and but rarely obese.

The conformation of the limbs is most characteristic, especially that of the thighs. These are well rounded, *arched anteriorly and laterally,* the latter being the most noteworthy feature. The lateral bowing has, in well-marked cases, associated with a broad pelvis, its point of maximum curvature a little below the trochanter. The lateral and anterior arching exists in both male and female, and in both sexes the pelves may be small. The upper arms are rounded, the shape being graceful; the forearms are not rounded, except in marked cases. The muscular development, even when excessive, does not cloak these appearances, some of the most marked cases having occurred in muscular male cadavers. The conformation of the thighs exists also in women with broad pelves. This configuration cannot be considered as a female type of build, but rather a persistence of the juvenile contour.

The skin most frequently has a glossy, less often a pasty appearance, as was first brought out by Escherich and Daut.

Hair.—The hair upon the pubis is distinctly feminine in distribution, confined to the suprapubic fat pad, the superior edge being sharply marked off. The hair may be abundant but it is never absent except in the young. A few hairs may extend up the linea toward the umbilicus.

Axillary hair in adults is usually scanty, although the individual hairs may be long. Hair on head may be abundant even in less marked cases. It is coarse, straight, and lusterless.

Hair on Limbs.—Even in subjects having the usual amount of hair, the thighs are, except for lanugo, free of hair, even when the legs and forearms are hairy. The same is true for the upper arms.

The **head** is brachycephalic in type.

The **neck** is implanted squarely upon the upper thoracic opening. It may be either long, thin, and columnar, or short and thick.

Genital Organs.—A few of the marked cases present evidences of infantilism, the external genitals being small. This infantile type of the genital organs is, however, exceptional, even in those cases associated with a hypoplastic condition of the aorta and arterial system. The glans penis is frequently pointed like an acorn.

Many of the above characteristics may be absent, the most *constant* being the *peculiarity of the thighs.*

Thus, the pubic hair may be normal or excessive, running up the linea in normal adult males. This is, however, exceptional.

Our experience at the morgue teaches us that the external appearances are of considerable importance in diagnosing the presence of the *status* cases, especially those which are recessive in type. It is certainly a striking fact that time after time, without clinical history, the diagnosis has been made before autopsy.

The Internal Appearances

Contrary to the usual statement, the superficial lymph nodes in our cases do not seem to participate in the general hyperplasia. In the well-marked cases, even in adults, there was found a hyperplasia of the faucial tonsils and of the lingual and pharyngeal and intestinal lymphatic structures, also of the splenic follicles and intraperitoneal lymph nodes.

In many the hyperplasia of the intestinal lymphoid structures, of the mesenteric lymph nodes and splenic follicles, is less marked, and in some is entirely absent. These lymphoid structures usually undergo recession before the faucial and lingual tonsils. In certain cases, the recession is beautifully indicated by the appearance of the Peyer's patches. Thus, one part of a patch may be flat, almost atrophic in appearance, whereas other parts present almost tumorlike masses. . . .

In the typical and also in the recessive cases, a *diminution of the caliber of the aorta* was noted; even more striking and constant were the thinness and elasticity of the wall. A slight hypertrophy of the left ventricle was frequently observed.

Our attention having been called to the observations of Wiesel and Hedinger, that there may be hypoplasia of the chromaffin system in *status* cases, we have found that the adrenals often are strikingly small and flat. In one case, where the freshly preserved material was studied, we found an entire absence of chromaffin substance in the adrenals and semilunar ganglia. . . . That the hypoplasia of the adrenals or the chromaffin cells is a constant finding in status cases, we are not prepared to concede without further study.

In our series of cases in the female, there is but one case with an infantile uterus, and no cases in males with undescended or incompletely developed genital organs.

Dr. Norris goes on to state that his studies are based upon approximately 80 cases, which he has divided into several groups, as follows: (1) Cases of sudden death in adults having *status*, without anatomical lesions. (2) Cases which cannot be considered idiopathic on account of indefinite previous illness. (3) Includes cases of disease of the ductless glands with which *status* is more or less constantly associated (Basedow's disease). Dr. Norris states that *status lymphaticus* and Basedow's disease are frequently associated lesions. (4) In another group of cases the *status lymphaticus* was observed in the bodies of individuals who had died of acute infectious diseases; among them epidemic cerebro-spinal meningitis, which in these cases of *status* runs a very rapidly fatal course. In the cases studied by Elser at the New York Hospital he concluded that there could be no doubt but that *status lymphaticus* was an important factor in determining the rapidly fatal issue in cases of epidemic meningitis. In the cases which survived for a longer period the condition of *status* was not found. Elser's observations further led him to the conclusion that in over one

quarter of the cases examined postmortem of epidemic meningitis, the *status lymphaticus* was present, and that the latter may, therefore, be regarded as an important predisposing factor to infection with epidemic meningitis.

Dr. Norris says that during the work on the two East River tunnels a considerable proportion of the fatal cases of CAISSON DISEASE were the subjects of *status lymphaticus*. The *status lymphaticus* has further been observed in several cases of typhoid fever.

Cases of *status* are peculiarly susceptible to poisons of various kinds, notably to chloroform and ether, to potassium cyanid, to alcohol, to arsenic.

THE PATHOLOGICAL CHARACTERS OF THE DISEASE

Dr. Norris says that

> Though the literature on the subject is very voluminous, it is impossible as yet to accurately define the pathology of the condition. The important features characterizing the lymphatic state as first delineated by Paltauf are the presence of a *thymus gland* which has failed to undergo the usual involution, together with a general lymphadenoid hyperplasia. The occurrence of a hypoplasia of the arterial system and genitalia was first pointed out by Bamberger and Rokitansky. The latter was also familiar with the persistence of the thymus in adult life and the combination of this with general lymphoid enlargement. To Ortner, among others, belongs the credit of associating those two conditions, and of emphasizing the increased susceptibility of its subjects to disease and sudden death.

Dr. Norris says that:

> Were all these features well defined and constant, there would be no difficulty in setting up a clear-cut definition of *status*. But this is far from being the case, as our experience has taught us that there exists every degree of this state. . . .

In regard to the thymus gland, Dr. Norris says:

> In these cases the thymus shows a progressive increase in weight from birth to puberty, reaching its maximum at fifteen years. During the next five years an abrupt decline followed by a gradual diminution occurs. . . .

But Dr. Norris observed that in the decade following puberty—namely, from twenty to thirty years, the average weight of the thymus considerably exceeded the normal, and says that:

> This would absolutely demonstrate either an arrested involution or a true hyperplasia and establishes, as he believes, the fundamental connection between hyperplasia of the thymus and *status lymphaticus*.
>
> Although the general lesions of *status* are constantly associated with an enlarged thymus, an enlarged thymus is not necessarily accompanied by *status*.

There follow in Dr. Norris's article a number of interesting ideas in regard to the relation of the thymus gland to this disease. The reader is referred to

Dr. Norris's paper for the details. I insert here Dr. Norris's conclusions as given in his article:

1. Status lymphaticus is characterized by hyperplasia of the lymphatic structures associated with persistence or enlargement of the thymus gland beyond the age of puberty, with arterial hypoplasia and possibly with hypoplasia of the chromaffin system.

2. Cases of this state have characteristic external appearances, especially in respect to general conformation of the body and distribution of the hair.

3. This constitution represents a constitutional anomaly, and not a mere persistence of the infantile type or an arrest of development. Infantilism is, however, not infrequently associated with it.

4. Individuals with this constitution have a special predisposition to disease, and increased susceptibility to various insults.

5. The frequency of the lymphatic constitution has not been sufficiently emphasized, nor has sufficient account been taken of it in its wide medical, surgical, and insurance aspects, especially its relation to prognosis and duration of life. We have found this condition in about 2 per cent of over 2,000 autopsies.

6. Not all the individuals with the lymphatic constitution succumb to disease. Many survive to adult age. The various lymphatic structures thereupon tend to undergo recessive changes.

7. The lymphatic constitution is noted with especial frequency in diseases of the ductless glands (Basedow's, Acromegaly, Addison's, and in tumors and diseases of the pineal gland) and in diseases such as epilepsy, which are probably due to disorders of internal secretion.

8. The thymus is an epithelial organ, and not a lymphoid structure.

9. More exact knowledge of the thymus, in its relation to general lymphoid hyperplasia, to the onset of spermato-genesis, and the development of the secondary sexual characters is vital to any further progress in the elucidation of important physiologic and pathologic consideration of health and of disease.

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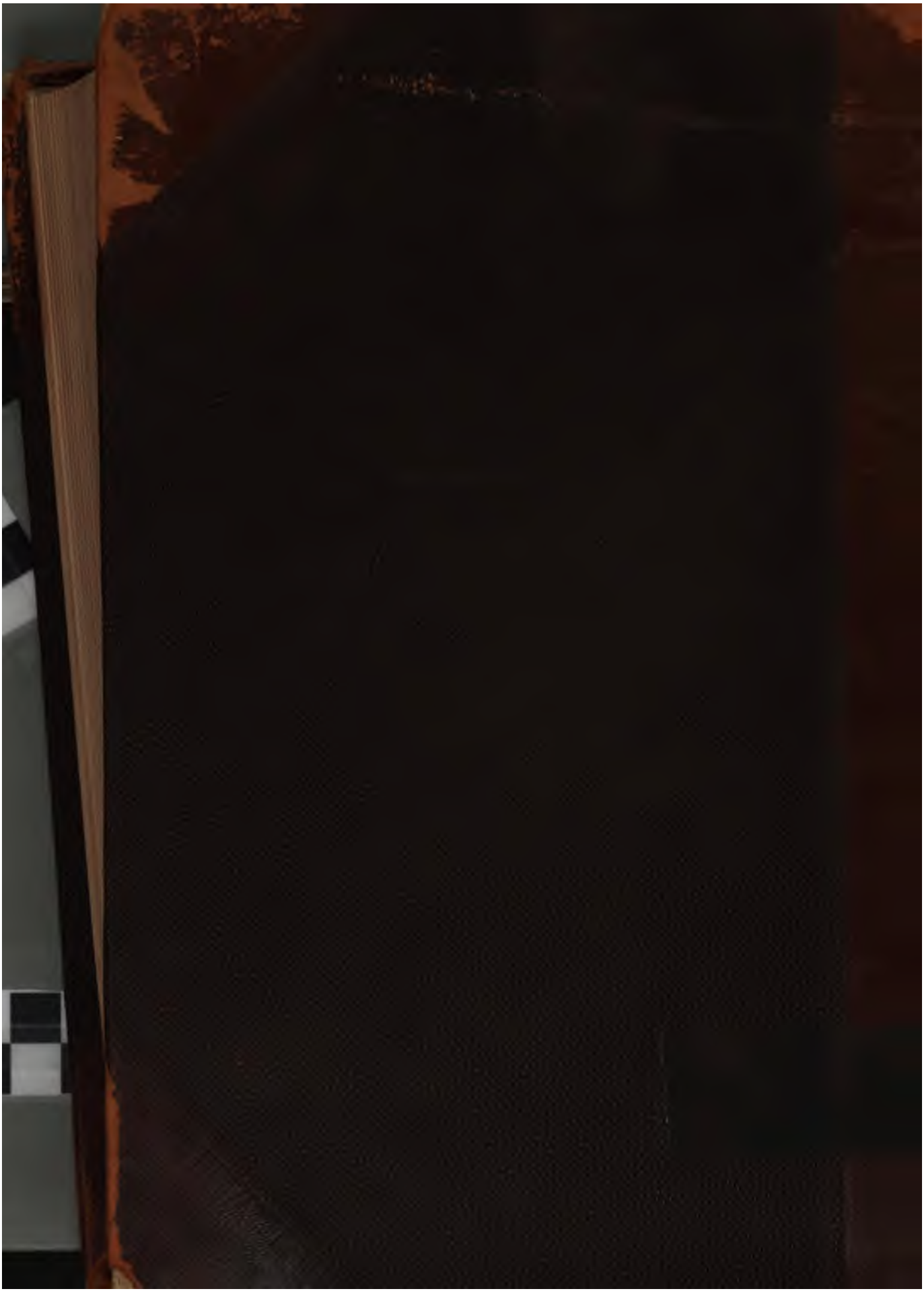
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